The AMSAT® Journal

Volume 25, No. 2 March/April 2002

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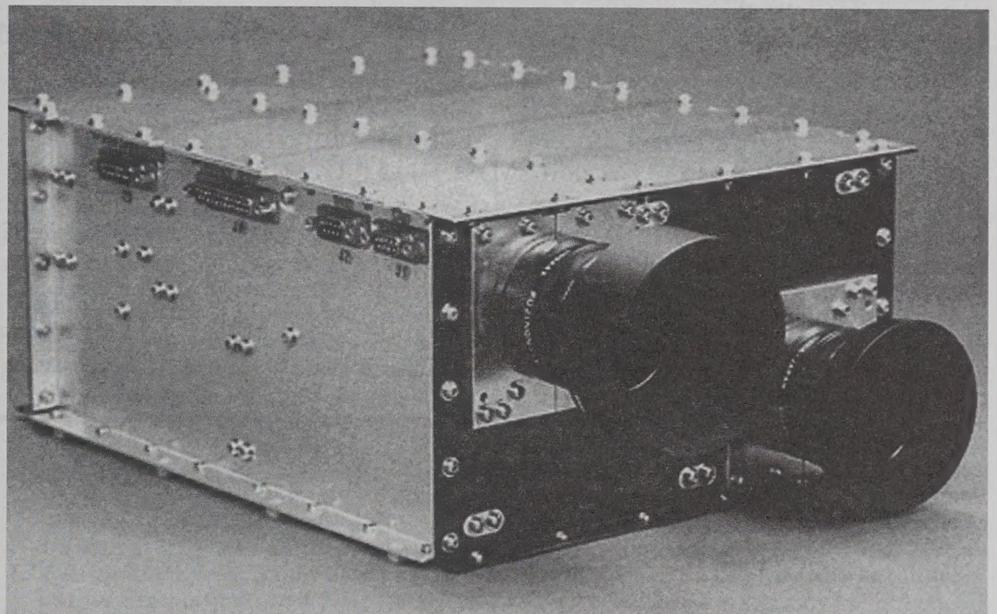

**JAMSAT-developed SCOPE camera is operational on the AO-40 spacecraft. The completed flight module is shown with both camera openings.**

# The AO-40 JAMSAT-SCOPE Project

## Yoshi Takeyasu, JA6XKQ (*Translation and Assistance by Tak Okamoto, JA2PKI; Jim White, WD0E; R. Zimmerman, DL1FDT; and, John Bubbers, W1GYD*)

JAMSAT made a proposal as early as 1990 to fly a color CCD camera as an experiment. The experiment, called SCOPE is an acronym for *Spacecraft Camera Experiment for Observation of Planets and Earth.* With plans for Phase 3D to become a three-axis stabilization radio amateur satellite, Phase 3D designers indicated great interest in such a project and encouraged JAMSAT to develop a SCOPE camera. In 1991 at the second Phase 3D meeting, JAMSAT presented the first briefing on SCOPE specifications. As a result, the following resources were reserved on the Phase 3D satellite:

**[continued on page 4]**

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07253 N8GN1 2003.05
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*The AMSAT Journal* (ISSN: 1407-3076) is published bi-monthly (Jan, Mar, May, Jul, Sep, Nov) by AMSAT-NA, 850 Sligo Avenue, Suite 600, Silver Spring, MD 20910-4703. Telephone: 301-589-6062, fax: 301-608-3410. Periodicals postage paid at Silver Spring, MD, and additional mailing offices. Postmaster, send address changes to *The AMSAT Journal*, 850 Sligo Avenue, Suite 600, Silver Spring, MD 20910-4703.



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# Apogee View

### by Keith Baker, KB1SF, Executive Vice President

The last issue of *The AMSAT Journal* contained an AMSAT Volunteer Survey form on pages 8 and 9. Both Robin and I trust by now that you all have seen it and, hopefully, some of you have actually filled it out and sent it in, or requested a copy online by sending an e-mail to volunteer@amsat.org. As with most volunteer organizations, AMSAT very much runs on volunteer support. And, while everyone may not possess the skills (or have the available free time) to actually work on our space hardware and software, there are always a number of other equally important tasks that need to be done to keep such a vibrant and exciting organization as AMSAT moving forward.

And, because we are all volunteers who are very busy trying to keep the organization on track, let me just say that the kind of people we are *really* looking for are what I call "self-starters." These are people who don't need to constantly be asked for their help or who continually need "hand holding" or reminding to do things. Such people thrive on leaping into new and unfamiliar situations with "both feet." They aren't afraid to make some mistakes along the way, and they also tend to approach things from a "find-a-need-and-fill-it" perspective. If you fit this description, have some needed skills, and also have some spare time you'd like to share with us, then you are *exactly* the kind of person we are looking for.

Also in the last issue, Robin alluded to the fact that our ***Eagle*** project was moving forward, and I am pleased to report that progress in that regard is continuing. However, we have also now added yet another (somewhat smaller) MICROSAT-class project to the mix that will no doubt keep our experimenters even more busy. I think you will find some of the capabilities that are now being planned for this new MICROSAT satellite will have something that each of us will find most interesting.

That's because many of you will recall the excitement we all shared (now over 12 years ago!) with the launch of AMSAT's first flock of MICROSATS. At the time, they represented a radical new design of smaller and lighter spacecraft that were later responsible, quite literally, for spawning an entirely new communications industry. Since that time, a number of commercial vendors have taken AMSAT's basic MICROSAT design and have adapted it to a number of very interesting commercial and scientific payloads.

I have always stated to anyone who would listen, that AMSAT's original MICROSAT design was elegant in its simplicity. It is a classic example of the KISS approach (Keep It Simple, Stupid) and I am very excited that, in many ways, we are now returning to our "roots" by again designing smaller, inexpensive and hopefully, far more standardized spacecraft for future missions. These designs will feature highly interchangeable spacecraft housekeeping hardware and software including standardized batteries, solar panels, onboard computers, as well as standardized uplink and downlink electronics, all as part of a basic satellite "bus" structure.

However, because there is space deliberately left over in the design, each satellite can be configured for a variety of different missions depending on the launcher used and the satellite's specific mission requirements. Interestingly, the builders of AMSAT's original MICROSATS (working well over a decade ago) gave life to this idea when they left space in their original MICROSAT spacecraft design for TSFR trays...TSFR standing for "This Space For Rent".

But, what may not be as readily apparent in these designs is that the ***Eagle*** project (and our new MICROSAT project) signal a radical departure from AMSAT's traditional way of managing and building our spacecraft. That is, in the past, AMSAT's satellite design heritage has tended to be "launch driven." We have usually waited until the ***exact*** parameters of the launcher were well known before proceeding with the design and construction of our spacecraft. This was done in order to better match those (often harsh) launch environments to what our experimenters later designed, built and launched.

While this approach worked very well for us when rocket launches were few and far between (and the launch environments were still very harsh, and all quite different), it simply no longer fits in today's space marketplace. These days, there's a growing variety of highly reliable and standardized launch boosters regularly being built and flown by a growing number of experienced launch providers. Some of these providers are now regularly carrying *scores* of standardized, commercial and scientific satellites into the cosmos every year.

So, doggedly clinging to our (admittedly) successful "build-the-satellite-to-match-the-launcher" approach to spacecraft design would continue to force us into "reinventing the wheel" each time we're offered a launch. We now believe that settling on a couple of common spacecraft designs (designs that can be readily adapted for a much wider variety of mission profiles) will make our satellites far more compatible with a much wider variety of launchers and launch agencies. This should also give us far greater flexibility to take more rapid advantage of (hopefully) lower cost launch opportunities as they inevitably come our way.

So, by employing this approach, the largest portion of any one of our spacecraft destined for any given launch might already have been designed and tested (or already have been proven on orbit in a previously successful satellite) when a new launch opportunity is secured. Or, the principal hardware for the next mission might already exist, having been built as the backup for a previous mission and is now simply sitting "on a shelf" somewhere waiting to be integrated into the next satellite. In either case, the only purely "experimental" **[Apogee View continues on page 7]**

Figure 1. The first image from the SCOPE-B in orbit was taken at an altitude of 45,000 km on 07 August 2001 at MA45 on AO-40's way to apogee.

**[Continued from page 1]**

Weight: 5 kilograms
Volume: 0.005 cubic meters
Power Supply: 5 Watts

Initially, SCOPE was planned to have three cameras with a telephoto, normal, and wide-angle objective lens. However, during the development process it became clear that it would be difficult to accommodate three cameras because of weight and volume limitations. Additionally, it was shown in the first studies of the stabilization system that it was not possible to aim the telephoto camera with the required accuracy and to take a picture of a planet without wobbling. Therefore, the SCOPE team decided to leave out the camera with the telephoto lens.

After the concept phase there was a transition to the hardware concept phase. At the end of 1993 a sample construction model was set up, which presented the basic function. In 1994 and 1995 the team created various functional models in order to test various concepts in detail and to decide on one. As a result, the final concept was decided on and the team thereafter busied itself with the creation and construction of parts for the flight model and the back-up model. During this period discussion took place with other AMSAT groups that led to improvements in the experiment. In 1996 the flight module was finalized and a list of tests were drawn up.

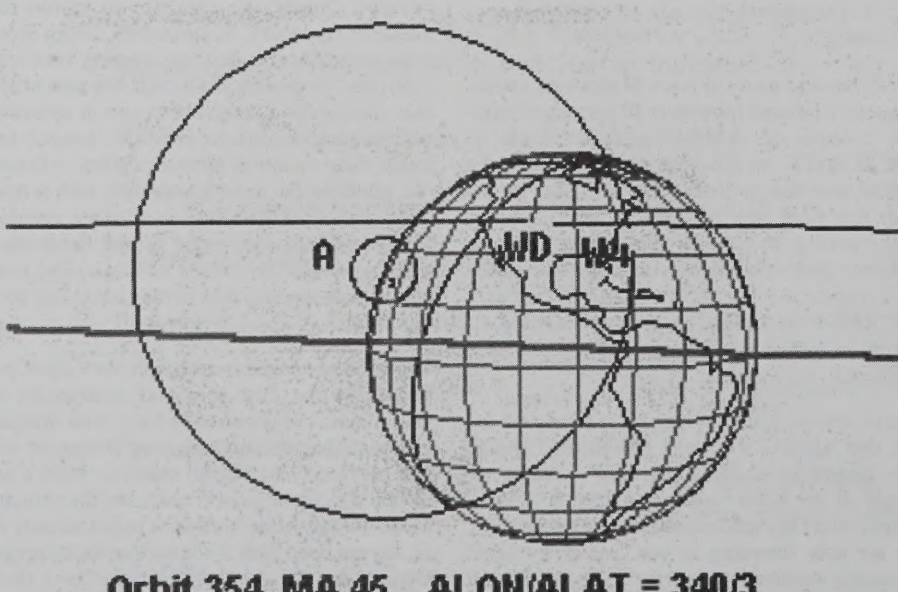


Figure 2. Command Station W4SM calculated this image section for the moment to make the 07 August 2001 exposure.

In a space simulation chamber the basic functions as well as the operation were examined in a vacuum and temperature environment. Characteristic data at various temperatures were gathered, as well as testing the entire system. In February 1997 the flight-ready module was handed over to the Phase 3D Integration Laboratory in Orlando, where the electrical and mechanical tests were successfully completed. On 7 August 2001 SCOPE sent its first picture from orbit. (*Editor's Note: See page 4 of the May/June 1997 and page 1 of the September/October 2001 issue of* The AMSAT Journal.) The Scope Project has the following three goals:

- To take color pictures of the Earth from a highly elliptical orbit. While there are already several amateur satellites with CCD cameras on board, they are in a low earth orbit (LEO) and deliver only monochrome pictures, like the ones the Apollo Mission astronauts were able to see on their trip to the moon, namely a suspended Earth in space.

- Support of the satellite's attitude control system as an Earth sensor: AO-40 with its three-axis stabilization system has the capability to determine its direction. The system is comprised of three reaction wheels, as well as Earth and Sun sensors. The SCOPE camera can act as a calibration aid and a replacement sensor for the attitude stabilization.

- Validation of SCOPE as a potential sensor for the attitude control system: For the trip from the Earth to another planet, a star tracker as sensor is needed for orientation. The SCOPE camera can easily recognize relatively bright stars, so it can potentially serve as a star tracker. SCOPE can also deliver good images of targeted planets. This function will be tested during the AO-40 mission.

### Mechanics

In a single module-housing there are two cameras: Camera-A with a narrow-angle and Camera-B with a wide-angle lens. Originally it was planned to have individual cameras in individual housings. Because of the satellite based weight and space considerations the cameras have to share a single housing. The module has a standard size of 297 x 297 x 130.6 mm (D x W x H), aside from its height. The SCOPE module with both cameras weighs 5.4 kg and is as light as the individual originally planned camera modules. This is the result of the reduction efforts relative to the weight and volume.

## Electronics

The electronics comprises five units: The CCD units, the processor unit, the memory, the A/D converter and the interface.

## CCD Unit

Originally a CCD with frame transfer and a chip with a strip-like color filter were going to be used. This type of building block simplifies the associated electronics. However, we discovered that the filter used is made of an organic material, which quickly deteriorates in a severe space environment, which is why we decided against this type of CCD.

Now we are using a 3-CCD unit, which is like the ones used in PAL cameras for industrial picture processing. The unit consists of a dichromatic prism to separate the colors and three CCD's with interline transfer for the colors of red, green and blue. The individual colors are separated in the prism into two dichromatic layers. These filters do not use any organic materials and are fully space qualified.

Technical Data of the CCD Unit:

- Image size = 1.27 cm
- Number of Pixels = 752 x 582 (Horizontal x Vertical)
- Pixel Size = 8.6 x 8.3 microns (Horizontal x Vertical)

These CCD image receptors are commercially available as replacement parts for professional cameras using the PAL standard. The image receivers can be readily modified to make them directly controlled by the processor.

## Optics

A normal zoom lens is used for the optics. The zoom function will not be used in space, and was set to a fixed focal length before the launch. Edge conditions limit the focal length because of interfering adjacent objects (V-band antenna) and the orbit, among others.

The exact zoom factor was only set up once the future orbit and the desired view of the earth was firmly established. Both cameras use the same zoom optics; various zoom factors were set up merely to realize various aperture angles. Only the aperture is variable. The opening of the lens is 41.5 mm, the field of view is 16°for camera A and 32° for camera B. Neutral gray filters are used (neutral density) which adapt to the brightness of the Earth. Three filters are used in tandem, one x4 and two filters x8 which gives a total factor of x256. The gray filters and their mountings are standard components that have been modified.

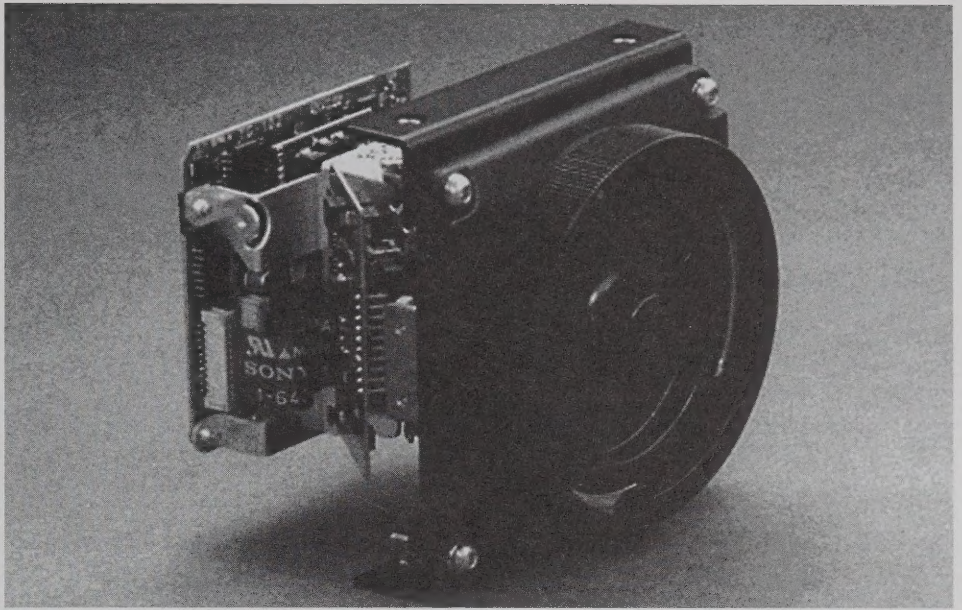

**Figure 3. The assembly with the three CCD's and the lens mounting.**

The usual grease used in the lenses would partially evaporate and condense on the lenses and interfere. In order to prevent this fatal deterioration of the optics, both lenses were disassembled, completely degreased and fitted with space-friendly grease. (A few grams of this grease costs $100 US). The focus was corrected for infinity. This is necessary since the refraction of the light rays in a vacuum is different than in the Earth's atmosphere. At an apogee altitude of nearly 60,000 km and a perigee of around 1,000 km, the following rough resolution of the objective lenses of the earth's surface results:

| | Apogee | Perigee |
|---|---|---|
| Camera A | 32 km/Pixel | 1 km/Pixel |
| Camera B | 64 km/Pixel | 2 km/Pixel |

## Processor

In order to keep the switching simple, SCOPE uses a TMP68301 with a 68000 CPU kernel. The building block has three UART channels, Timer/Counter, Address-Decoder, Wait Generator, Interrupt-Controller, and a 16-bit parallel port, with everything on one chip. The clock frequency can be switched between 16 MHz and 8 MHz to be able to reduce current consumption.

A boot ROM with corresponding boot routines, the space-proven HM6617 (fused link ROM) is used. This ROM type is widely known to be very reliable, even in space. EPROM's which are widely used in Earth-based computers, should not be put into space, since the installed data contents

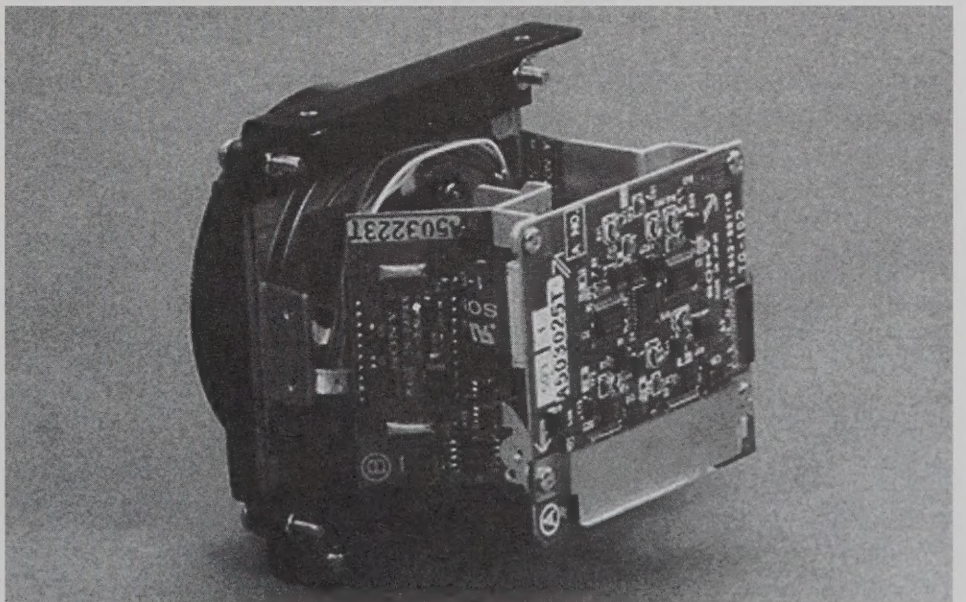

**Figure 4. SCOPE image printed circuit boards.**

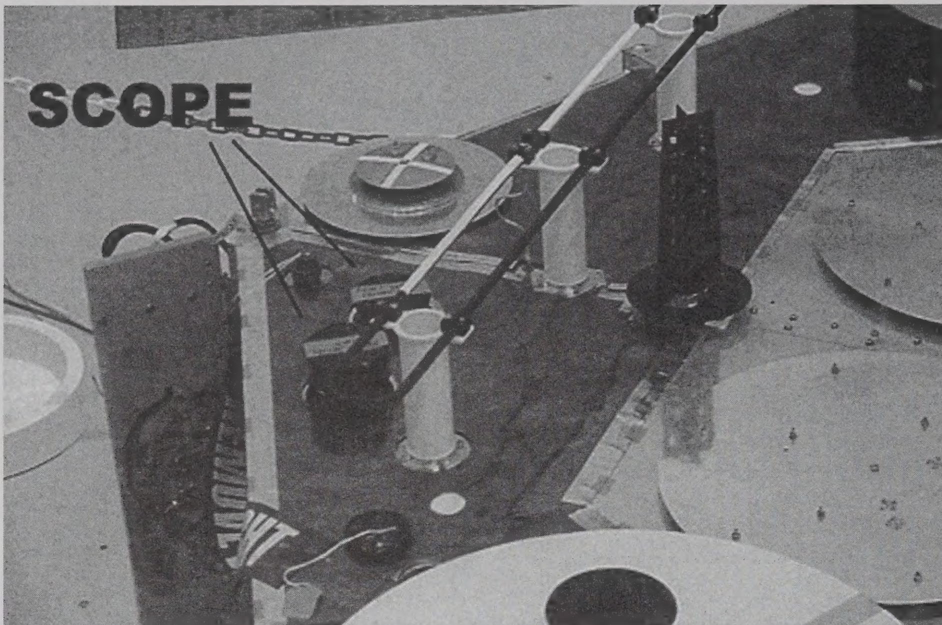


Figure 5. The location of the objective lenses on AO-40. The VHF dipole antenna limits the viewing angle.

Figure 7. The SCOPE-A lens.

Figure 8. The lens for SCOPE-B has a different.larger aperture.

could be erased by radiation. Each SCOPE camera has two Fuse-Link ROMS that are connected for redundancy.

The processing unit contains, among other things, an RS-485 asynchronous port, as well as a CAN Bus-Connection (Control Area Network) which communicates with the other modules in the satellite, to load the program code, and to swap commands and image data.

### Memory

The memory consists of 4 megabytes of static RAM (HM628512 SRAM) of which 1 megabyte is equipped with EDAC (Error Detection And Correction). The building block IDT39C60 provides for the tracking and correcting of unwanted changes. Such changes can occur from strong radiation, so-called SEU's (Single Event Upsets), which are common in space. Unwanted changes in the software can lead to crashing the system. The program code is stored in the EDAC memory (error correcting memory), and the less sensitive image data is kept in the regular memory.

### A/D Converter

The A/D converter unit consists of three identical converters, one each for red, green, and blue CCD chip. Each converter has a resolution of 8 bits, and, in total, it results in a color resolution of 24 bits (16.7 million colors). There is amplifier with an adjustable gain (gain factor of 1 to 8) between each CCD and it's A/D converter with which the signal level can be adjusted. The output signals of the A/D converters are passed to the 3 megabyte non-EDAC-memory from the processor. The A/D converter also contains the driver and temperature control circuits for the CCD block.

### Voltage Supply

The voltage supply unit receives 10.6 Volts from the satellite's main voltage bus and produces +5 V, +15 V, and –9 V to provide for the SCOPE unit. A flyback circuit was built with the IC LM2577 switching regulator. To distribute the load uniformly, two similar circuits were built one of which produced only +5 V, the other +15 V and –9 V. The power demand was about 5 Watts per camera, which approaches the originally planned value.

### Connections to Other Systems on the Satellite

The IHU and RUDAK are directly connected to the SCOPE camera. Each of the two cameras is switched on and off by a single bit from the IHU. SCOPE communicates with RUDAK via the CAN bus or alternatively

via an RS-485 multi-drop connection. SCOPE, thereby, makes its eyes available to RUDAK, in a manner of speaking, in exchange for which RUDAK represents the ears and mouth for SCOPE. SCOPE waits for new code in the first place, which can be loaded in the middle of the boot ROM, and on the other hand, the commands conveyed via RUDAK can be evaluated on the CAN bus. The images taken by SCOPE are forwarded to RUDAK, stored there and passed along to the ground station at a later time. The RS-485 multi-drop connection serves as a backup for the CAN bus, on which both cameras are connected to RUDAK. ■

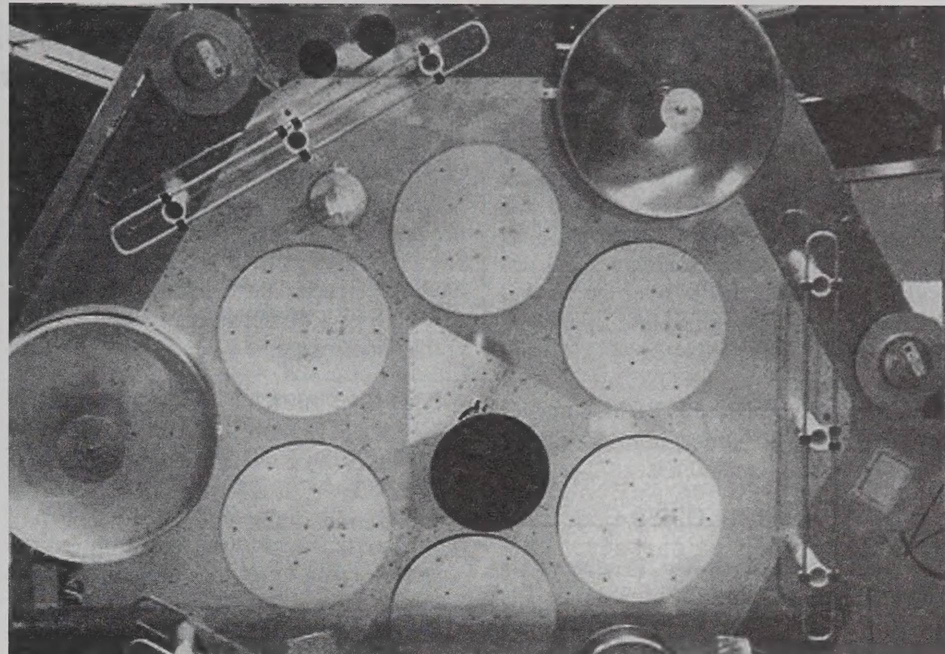

**Figure 8. A self portrait of AO-40 and the SCOPE camera. This innovative photograph was taken with a mirror placed in front of the SCOPE camera at the Phase 3D Integration Laboratory, Orlando, Florida.**

**[Apogee View continued from page 3]** part of that new satellite project remaining to be built would most likely just be those things housed in the TSFR trays. It would follow that this approach should help make our future spacecraft even more reliable once they are in orbit.

Now, I know this approach may sound a bit like a "cure-all" against on-orbit failure. However, despite our current plans to make our spacecraft more standardized (and hopefully more reliable) the uncertain nature of what we do will, unfortunately, continue to be with us. Put another way, our grand new vision for how we build and launch our satellites will remain firmly rooted in the squishy realm of "rocket science"... at least for the foreseeable future.

On a more personal note, let me also say that it is great to be back serving as your Executive Vice President. My thanks to Ray Soifer, W2RS, for your many (many) years of faithful service to AMSAT and for your outstanding efforts in keeping this particular chair "warm" for us in the past. While we will now sorely miss your hands-on help "at the top", both Robin and I are very pleased that you will be staying on as our VP of International Affairs.

I again look forward to serving all of our members as a senior officer in your organization. I welcome your ideas and your comments as well as any "hands on" help you can spare as we continue to move forward...together. ■

# A Satellite Antenna Control Unit Using FODTRACK

**Jesse Morris, W4MVB (*w4mvb@juno.com*)**

When I returned to the air regularly in 1995 after many years of very little activity, I was the Amateur Radio equivalent of Rip Van Winkle. Although I had operated intermittently at sea, on board research vessels, and worked some 2 meter FM over the years, I had not attempted any satellite operations since the time I was captivated by OSCAR 1 (and 2) and frustrated by OSCAR 3. After acquiring a used Yaesu FT-107M, I made a few HF contacts but almost immediately my interest returned to satellites.

### Rekindling The Fire

I made a few contacts on RS-12, transmitting with the Yaesu and a hastily built dipole. For receive, I used an old US Navy surplus R1051 receiver and a *longwire* antenna inside the garage! Soon though, I began to think about VHF operations. I remember having two distinct thoughts at the time. The first was just how easy it was to work a satellite now (the Rip Van Winkle Syndrome). I struggled through the short life of OSCAR 3 in 1965 without ever making a two-way contact. I was there for almost every available pass and did everything I knew how to do without success. I was ill equipped with both hardware and knowledge to accomplish the task. We didn't have computers to drive the antennas or to provide look angles back then. We didn't even have calculators and I didn't have an OSCARLOCATOR. Since I didn't have elevation control, I knew my best chances were the orbits that were low enough on the horizon to be within my vertical beamwidth and high enough to reduce the path loss. But I never made the grade. My best result was to be listed in *QST* as having been heard through the satellite. Even that meager accomplishment was a considerable thrill for me.

My second impression was that of *sticker shock* (the syndrome again). After building a 2 meter transverter along the lines of the one published in the 1994 edition of the ARRL *Radio Amateur's Handbook*, and modifying a 30 year old Johnson 6N2 transmitter for linear operation, I began to look at antenna systems. I realized very quickly that if I were going to purchase an AZ-EL antenna system for 2 meters I was going to have to spend three times as much as I had already invested in the used Yaesu transceiver and the 2 meter transverter. Since that was not an acceptable option at the time, I shuffled off to the attic in search of a 30 year old CDE TR-44 rotator. I replaced the motor phase shift capacitor in the control unit and the position potentiometer in the rotator unit and it seemed to work OK, so I bought an M2 14-element crossed Yagi and installed it on the mast at about 15 degrees elevation. I also built a 6-element quad and installed it at about 45 degrees elevation. For overhead passes, I used a homebuilt version of the Eggbeatter. All I had to do was switch antennas as the satellite changed elevation.

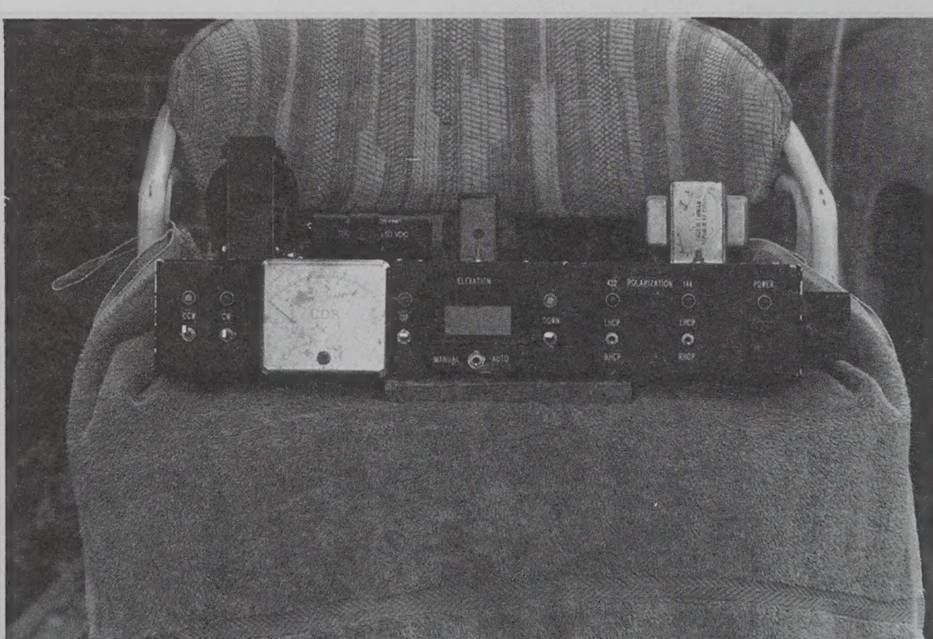


**Figure 1. Original antenna control unit and power supply.**

The antenna system worked very well for an uplink into RS-10/15 and FO-20/29. Needless to say I was pleased with myself for having put together a very workable satellite antenna system at a cost I could afford.

### Moving On Up

My satisfaction didn't last long. After completing a Down East Microwave 70 cm Transverter kit, I needed an antenna system suitable for working AO10 and FO-20/29. My first inclination was to follow the path I had taken for 2 meters but I quickly learned that such a simplistic approach didn't work very well at 435 MHz. I needed elevation control. I also wanted computer control of the antennas. Examination of off the shelf hardware indicated nothing had changed since I last considered that option. A major outlay of cash seemed necessary to obtain the system I needed.

### An Alternate Solution

As luck would have it a TV type antenna rotator, a Gemini model *Orbit 360*, showed up on the market for a brief period at just about the time I was looking for an elevation rotator. It was an ideal candidate for the job. It was built to allow the mast to pass all the way through the rotator much like the Alliance U100 and U110 rotators but it had a feedback potentiometer built in. It was easy to mount on it's side and was reasonably priced. (Later *Orbit 360* models were made differently and were not suitable for this purpose.) I had elevation control and I hadn't spent a lot to get it. I was half way to my goal. I now only needed to add computer control. The FODTRACK computer interface system designed by Manfred Mornhinweg, XQ2FOD seemed to offer what I needed. It was simple, effective and the cost was something I could afford. Manfred described his system in detail in the May/June 1996 issue of *The AMSAT Journal*. A file containing the schematic, PCB layout and the latest version of the FODTRACK program is available for download on the AMSAT-NA website.

### The Azimuth Controller

Although FODTRACK was designed to drive the Yaseu antenna rotator system, I was sure I could adapt it to the rotators I was using. My initial idea was to use relays to interface with the existing control units but after some research I decided to build a new control unit from scratch. The azimuth

controller was built around a circuit described by Howard Sodja, W6SHP in the May/June 1996 issue of *The AMSAT Journal*. In the first version (I call it the prototype) of the control unit, shown in Figure 1, I used the azimuth analog meter from the original TR-44 control unit. The unit includes the azimuth controller, the elevation controller with digital readout, the FODTRACK interface, a power supply and switches to control antenna polarization. This version of the control unit has worked very well for about four years. I used the analog meter for azimuth because I sometimes use the antenna system for terrestrial contacts and since most of the VHF/UHF activity is north of my location it was convenient to have the antenna stops at south. After AO-40 was launched, I decided to build a new version of the unit with digital readout in both azimuth and elevation and to separate the antenna control unit from the power supply unit.

Figure 2 is the schematic diagram of the latest version of the azimuth controller. The circuit uses optoisolators, U1 and U2, and triacs, U3 and U4 to drive the rotator motor, and is exactly as described by W6SHP in the article referenced above. The inputs to U1 (counter-clockwise) and U2 (clockwise) come from front panel mounted switches for manual operation or from FODTRACK for automatic tracking. Grounding the control lines causes current to flow in light emitting diodes (LED's) between pins 1 and 2 inside U1 and U2. This light is captured by an internal photosensitive device which turns on the triacs (U3 and U4) through pins 4 and 6. CR1 and CR2 are LED's that provide visual indication of operation. The LED's perform no functional purpose and may be omitted from the circuit. The value of 330 ohms for R1 and R2 was correct for my installation to maintain the control current in U1 and U2 above 25 mA (and below 50 mA). If you don't use the LED's or if you use a voltage level higher than my approximately 12.8 VDC you might need to change these values. Measure the voltage drop across the resistor, calculate the current and adjust the value of the resistor if necessary. W6SHP's value of 470 ohms should be just about right for 13.8 VDC operation with no LED's. The 180 uF 50 VAC phase shift capacitor should be the original (or the same value) capacitor for the rotator being used. T1 is the original transformer from the TR-44 control unit but any 115 VAC to 24 VAC transformer with a current rating of 1 to 2 amps could be used. The pin numbers on the schematic are for the TR-44 rotator. The TR-44 has limit switches built into rotator. In the absence of these limit switches, connect pin 2 of U3 to one side of the motor winding and pin 2 of U4 the other side. Connect the phase shift capacitor across the winding. This capacitor is installed in the motor housing of some rotators and in the control unit of others. The capacitor is in the control unit in my system (it can be seen on top of the chassis in figure 1). If the rotator does not turn in the proper direction, reverse the connection at the output of U3 and U4. This circuit would also be ideal for an elevation controller driving a U100/U110 providing a suitable position potentiometer were installed. It could also be used to control a variety of other rotators powered by 24 VAC but it does not include a provision for brake control. Dick Jansson, WD4FAB described a similar system with a brake control circuit in the 1994 edition of the ARRL *Radio Amateur's Handbook*.

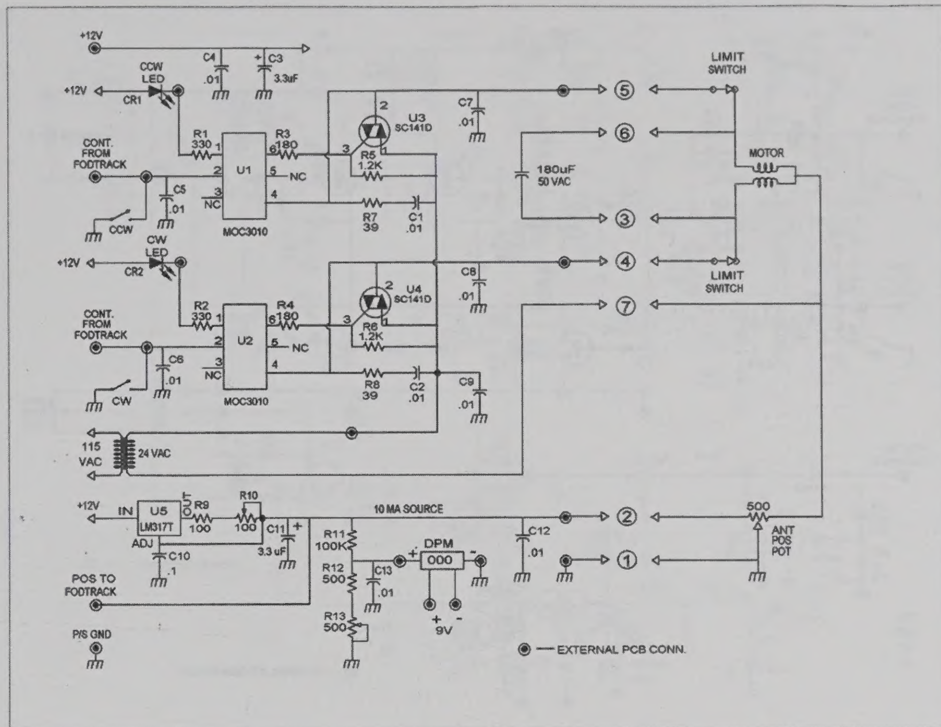


Figure 2. Azimuith control circuit schematic.

The TR-44 control unit uses a 10 mA constant current supply to feed the 500 ohm position potentiometer (its actually hooked up as a rheostat) which drives the analog meter circuit. This 10 mA source is supplied to one end of the resistor while the wiper is connected to ground. This results in 0 to 5 VDC being generated as the rotator is rotated through 360 degrees and the resistance of the rheostat varies from 0 to 500 ohms. The connection between the other side of the 500 ohm potentiometer and the common connection on the drive motor is left over from the original control unit circuit where

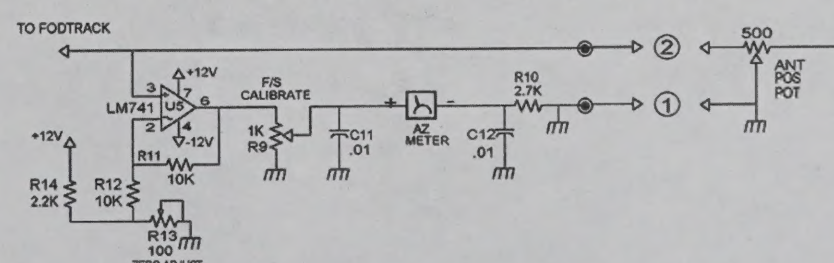


Figure 3. Azimuth analog meter driver circuit.

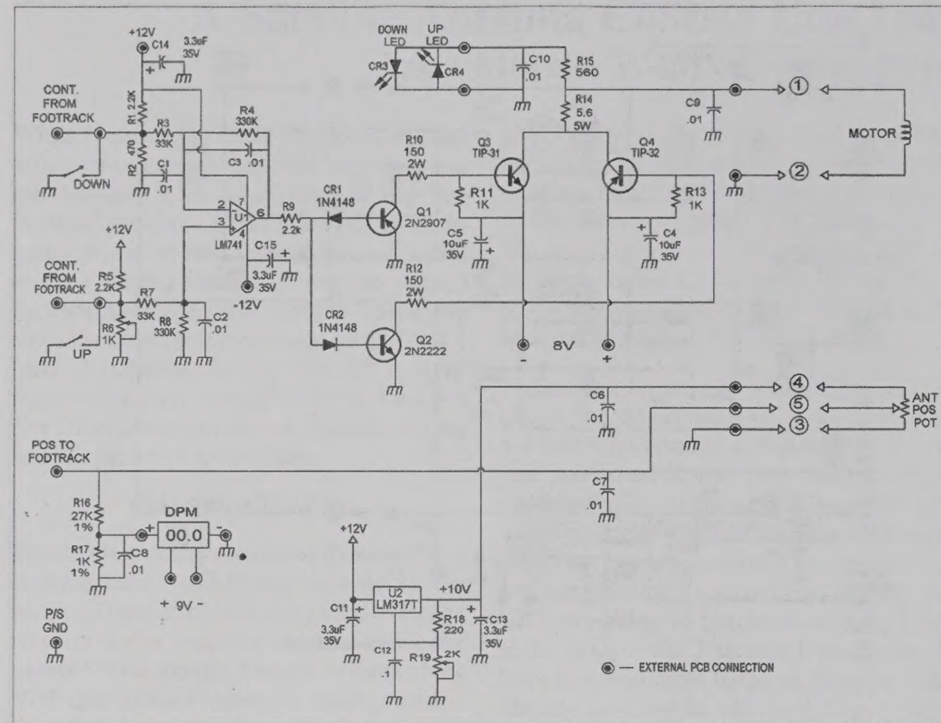


**Figure 4. Elevation control circuit schematic.**

one side of the constant current supply was common with 24 VAC common. I could have removed the connection in the rotator but didn't think about it when I had it open. U5 along with R9 and R10 provides this constant current source to the azimuth rheostat so the circuit operates in exactly the same way as in the original controller. The resultant 0 to 5 VDC is fed to the meter circuit and to FODTRACK for automatic tracking. Resistors R11, R12 and R13 are used to divide the voltage from the antenna position potentiometer for proper readout on the digital panel meter (DPM). This device is basically a 0 to 200 mV meter with jumpers to convert it to higher ranges and to enable the decimal point. To calibrate the circuit, rotate the antenna fully CW and adjust R10 for exactly 5 VDC at the input to FODTRACK. Then adjust R13 to provide a reading of exactly 36 mV on the azimuth meter. In it's conventional mode the meter would read 36.0 at that point but if the decimal point is disabled then the readout becomes 360. In this configuration the meter will read from 000 to 360 as the voltage from the antenna varies from 0 to 5 VDC. U5 can be modified to supply a conventional position potentiometer with 0 to 5 VDC (or 0 to 10 VDC in the case of an elevation rotator). The elevation controller schematic, Figure 4, shows the schematic for that circuit. For those who would like to maintain the analog meter for azimuth indication just eliminate R11, R12, R13 and the DPM and use the circuit shown in Figure 3 instead.

### The Elevation Controller

Since the *Orbit 360* has a DC motor, a different control circuit is required. The controller schematic, shown in Figure 4, is perhaps more complex than it needs to be. That fact resulted from my initial plans to use the existing control unit and adapt it to FODTRACK. I had already drawn the schematic of the existing circuit before I decided to build a new unit from scratch, so I simply utilized the original circuit and modified the input to U1 to suit the purpose. U1 is a DC opamp supplied with both plus and minus 12 volts. As was the case with the azimuth controller, the control inputs to U1 come from front panel control switches for manual operation or from FODTRACK for automatic tracking. I added CR1 and CR2 to provide a measure of noise immunity to the circuit, and although that may not have been necessary, the inclusion of these diodes does not materially affect the circuit operation. The output of U1 turns on control transistors Q1 or Q2 which in turn drives Q3 or Q4. When an "UP" (or "DOWN") control line is grounded by a front panel switch (or FODTRACK) the output of U1 goes negative (or positive), turning on CR1 and Q1 (or CR2 and Q2) which turns on Q3 (or Q4) providing a negative (or positive) voltage to the antenna motor and lighting LED CR4 (or CR3). Whether the polarities described actually drive the antenna up or down in elevation depends on how the rotator and antennas are mounted. If the antenna does not drive in the proper direction you can reverse the mounting of the rotator (and antennas) or reverse leads 1 and 2 to the rotator motor (much easier but may not match front panel switches and indicator!) It's best to get this all worked out and mark the rotator accordingly before mounting it on the mast. I have labeled the drive voltage for the rotator motor as plus and minus 8 volts but that's just an arbitrary value. The voltages are provided by sepa-

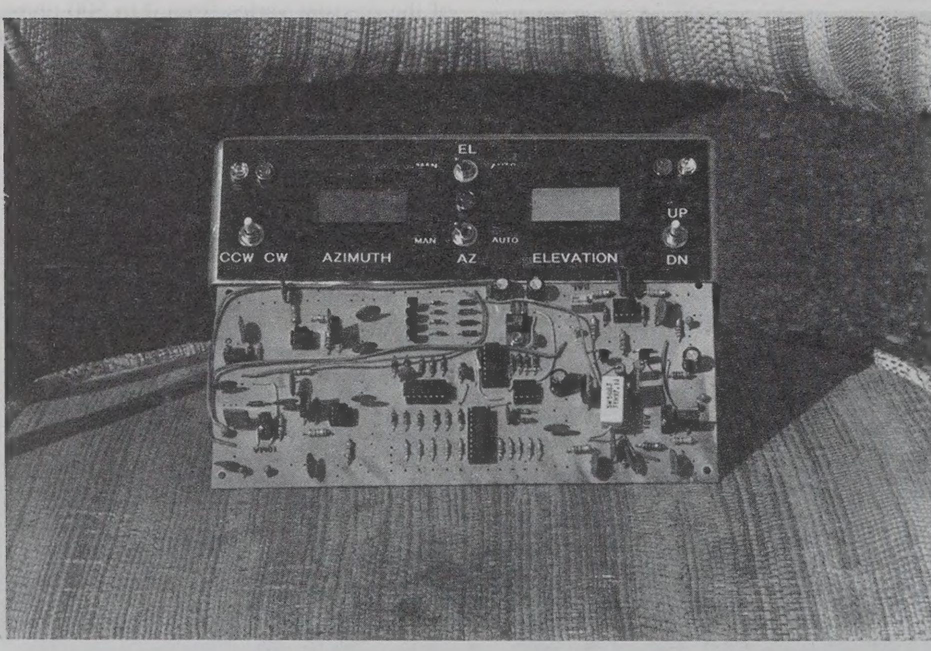


**Figure 5. New version of antenna control unit and printed circuit board.**

rate plus and minus adjustable power supplies (Figure 6). The original drive voltages were nominally plus and minus 12 volts but I found that voltage caused the antennas to move too fast. Somewhere between 8 and 10 volts seemed to be about the optimum voltage. With no input from FODTRACK and the front panel control switches open, adjust R6 for zero volts at pin 6 of U1.

U2 provides plus 10 volts to the position potentiometer in the antenna. FODTRACK wants to see 0 to 5 VDC for 0 to 180 degrees of elevation change. The *Orbit 360* has a 1k ohm potentiometer installed instead of the usual 500 ohms but it works just as well as long as 10 volts is maintained. As a mater of fact, the rotator has a 1K ohm fixed resistor in series with the center tap of the potentiometer but since the input resistance of FODTRACK and the DPM is so high, this resistor does not materially affect the operation of the circuit. Resistors R16 and R17 are used to divide the voltage from the antenna position potentiometer for proper readout on the DPM. Fortunately standard 1% value resistors are available to divide 5 VDC down to almost exactly 180 mV. Since the DPM can display 200 mV with one decimal point accuracy, the decimal point can remain enabled for this application. For calibration, elevate the antenna to 90 degrees and adjust R19 for an indication of 90.0 on the elevation meter. Use an external digital voltmeter and check for a voltage level of 2.5 VDC at the input to FODTRACK.

### Putting It All Together

Figure 5 shows the new version of the antenna control unit (the production model) with digital readout for azimuth. The figure also shows the azimuth, elevation and FODTRACK printed circuit boards which are ready to be installed in the enclosure. Although the picture indicates a single board there are, in reality, three separate boards. I was unable to get all three boards (each of which measures 4 inches by 3 inches) into the enclosure I had available so I merged the three PCB patterns together and overlapped the ground planes on the inside borders before I printed the patterns. I gained about ¼ inch by doing so and that was just enough to allow the combined boards to fit in the enclosure. The simple controller circuits don't really require a printed circuit board but I used this project to learn how to use an old freeware DOS based PCB layout program I downloaded from Protel, Inc. I also made a new layout for FODTRACK to make it compatible in size with the other two boards. I tried to make my layout identical to the original but I'm not as talented (or clever) as Manfred, since I needed several jumpers on top of the board to complete the circuit. It was an interesting exercise for me, however. I currently use the "Press-N-Peel" system for making printed circuit boards and I have the patterns required to make those type boards for the azimuth and elevation controllers along with component location overlays. I will send copies to anyone who wishes to use them. An SASE would be appreciated. I have heard, but cannot confirm, that a PCB for FODTRACK is available from FAR Circuits, Inc.

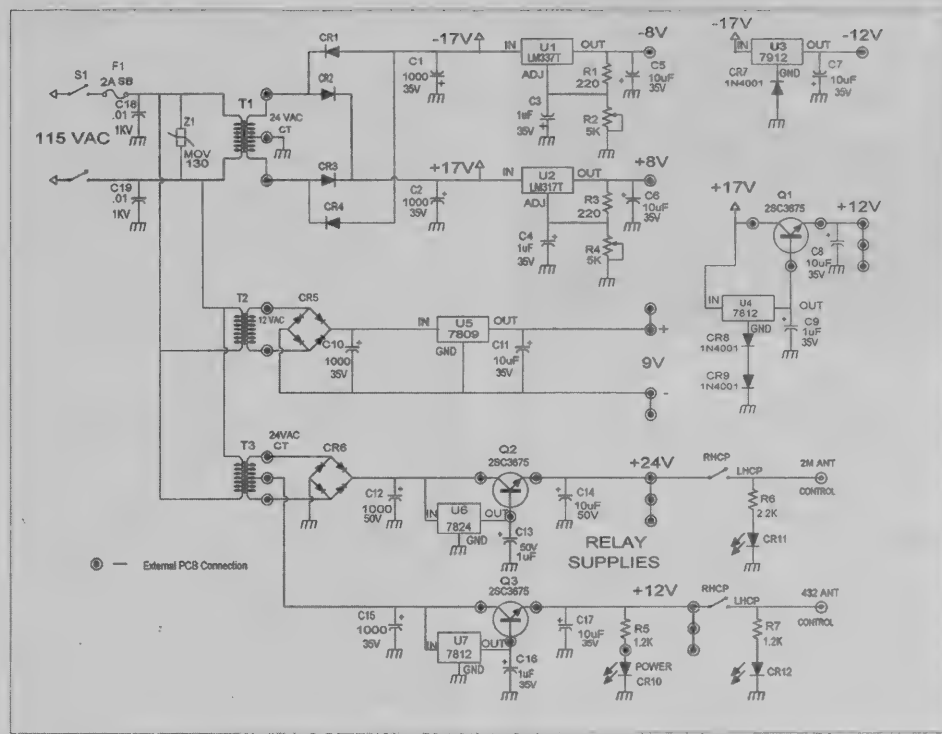


Figure 6. Power supply schematic.

There are only three connections between each of the controller circuits and FODTRACK. (See the FODTRACK interface schematic referred to above.) The output from the antenna position potentiometers (0 to 5 VDC for azimuth and 0 to 10 VDC for elevation) is provided to FODTRACK as an input. FODTRACK provides clockwise (cw) and counter-clockwise (ccw) signals to the azimuth circuit and up and down signals to the elevation circuit. Switches on the front panel of the antenna controller perform these functions for manual operation. I used separate SPST momentary switches for "CW"/ "CCW" and for "UP"/ "DOWN" manual control on the first model of the control unit. I chose SPDT center off momentary switches for the later model to save panel space. I should have used single bi-color LED's for the azimuth and elevation indicators but I didn't think of that until after I drilled the holes! There is a provision on the FODTRACK board to enable and disable automatic tracking with a switch which connects or disconnects the common emitters of the output transistors to/from ground. In the original unit I had a problem with interaction between azimuth and elevation manual controls. I was never able to figure out the problem so I solved it (actually I bypassed the problem) by permanently grounding the enable lead on the FODTRACK board and running the collectors of the four output transistors through a 4PST switch for automatic/manual mode selection. I expanded on that theme in the new controller by running the azimuth and elevation control lines through separate DPST switches so I could enable automatic operation separately for azimuth and elevation. The ability to do that is useful when a satellite passes through the antenna stops at the very beginning or end of a pass. The FODTRACK program does support *antenna flipping* but I don't use it so the individual enable capability comes in handy.

### The Power Supply

The power supply is shown in Figure 6. It is a multi-purpose supply that I use to power the antenna control unit, to power antenna T/R relays, control antenna polarity switching and to supply 12 VDC to preamps and a variety of other small devices. Not everyone will need all of the supplies. The transformers specified are those that are commonly available and although they may not be ideal,

they will work very well for this application. Well-designed 12 VDC supplies normally require around 17 VAC input but in low current supplies a DC voltage of nearly 1.5 times (actually 1.414 times) the AC voltage can be obtained if the DC filter capacitors are large enough. This was (and still is) a favorite trick used in building high voltage supplies for linear amplifiers in the early days of HF SSB. Actually I use a single transformer for T1 and T2 which was *liberated* from an old Sony Beta VCR. It contains a 24 VAC CT winding and a 12 VAC winding. Older VCR's often contain power transformers which can be used for small low voltage power supplies. The secondary of T1 can be rated at 1 amp or even less for powering just the antenna control unit and in that case the pass transistor, Q1, is not required. Just take the output from U4 and eliminate (jumper across) CR8 (or CR9). If you plan to use the supply to power other equipment, increase the current rating of T1 accordingly and maintain the pass transistor circuit. I used external pass transistors in the plus 12 VDC and 12 and 24 VDC relay supplies to increase the current availability and to reduce the power dissipation of the IC regulators so they would not require heat sinks. I used 2SC3675 transistors because I had some on hand but just about any high power NPN transistor will work. TO-220 case styles (especially all plastic devices) are easier to work with than TO3 case styles. Just bolt TO-220 devices to the chassis or other metal enclosure using heat sink compound (and insulating hardware if the transistor has metal on the back of it's case). You can solder external connections directly to the leads so you don't need a socket. I installed CR8 and CR9 in the ground lead of U4 to raise the output of the plus 12 VDC supply a little above 12 volts in order to provide more *overhead* for the 10 volt regulator, U2, in the elevation control circuit. CR7 was placed in the ground lead of U3 to match the minus 12 VDC supply to the plus 12 VDC supply (well almost match). T2 can have the smallest current rating you can find. The rating on the secondary of T3 depends on the number (and types) of relays to be powered. I use a transformer rated at 2A and power up to four relays at one time (and I'm planning to add more!). Of course you may not need this transformer and associated circuits at all. Additionally, if you use PM-102B DPM's, T2 and associated circuits will not be necessary. The five volts required for those DPM's could be obtained from plus 12 VDC through a regulator. Even if you use PM-128 DPM's, the current drain is so low that a 9 volt battery could be used for power. Finally if you do not use the DC version of the controller (elevation circuit) or the azimuth analog meter circuit, then U1, U2 and U3 will be unnecessary.

### Parts Availability

Most of the parts are described on the schematic diagrams. Most are common values and available from a variety of sources including Radio Shack. The LED's used are all *garden variety* available at Radio Shack and many other places. Choose your own color. The digital panel meters are available from a number of suppliers also. I used model PM-128 LCD from All Electronics (www.allelectronics.com). This model requires a separate (isolated ground) 9 VDC power source. Model PM-102B, also available from All Electronics, might be more appropriate. It is an LED and can be powered with 5 VDC using a ground that is common with the circuits being measured. I obtained SC141D triacs used in U3 and U4 of the azimuth controller from All Electronics also. MOC3010 optoisolators used in U1 and U2 of the azimuth controller are available at Radio Shack (and at other suppliers) and I got the one percent resistors, R16 and R17 in the elevation controller, from Digi-Key (www.digikey.com). Unless otherwise specified on the schematics, all resistors can be ¼ watt. I laid out all the circuit boards for ¼ watt resistors but I did "shoehorn" some ½ watt resistors I had on hand onto the boards. All electrolytic capacitors on the PCB's are radial lead type but axial lead devices will probably work better for some methods of construction.

### Conclusion

I designed this project in the hope that different parts of it would be of interest to different people. It is unlikely that many people will have the exact same parts and pieces I had lying around the shack. I hope the ideas presented here will help and encourage someone with a project they are planning. I also hope this presentation will encourage others to share their ideas and designs. After more than 40 years in our hobby I still enjoy building things. It's not necessary to know and understand everything about a project before you begin. A large part of the fun is the discovery along the way. ■

# Telemetery Beacon For VUSAT

## T. K. Mani,VU2ITI, Technical Committee Member, AMSAT-India

*Editor's Note: For additional information on VUSAT see page 31 of the November/ December 2001 issue of The AMSAT Journal.*

This beacon controller prepares telemetery data available on board of the VUSAT for transmission in Morse code so that the ham radio operator can decode the information without costly or complex equipment. The design strictly follows the KISS concept. It uses low cost, easily available components throughout the design. A block diagram of the beacon controller is shown as Figure 1.

The controller can accept 16 single-ended data channels where the dc level represents the parameter to be telemetered. These channels are selected one by one (multiplexed) by using two CD 4051 (analog MUX) ICs. Voltage from the selected channel is given to the ADC chip which converts the voltage to its digital equivalent. A channel counter (4-bit binary counter) controls the channel selection. This counter counts every clock pulse given to it and thus gives a 4 bit binary output. This binary number is given to the analog mux as the address of the channel to be selected. For every clock pulse to the counter, successive channels are selected. The channel-select clock is derived from the end of message signal (**EOM**), which will be explained later. The ADC chip used is AD7574. This chip is an eight-bit successive-approximation type ADC made by 'Analog Devices'. This ADC starts converting the analogue voltage input when the **RD** signal goes low and the digital value is available at the output pins approximately 15 microseconds later. The **RD** signal is derived from the **EOM** signal available from the EPROM.

The eight-bit-binary output from the ADC is given as the address of the 8 most- significant bits of the EPROM through two quad 2-input multiplexer chips. These two chips form an 8 bit 2-input multiplexer, one input being the 8-bit binary from the ADC and the other being the channel address (4 LSBs of the upper nibble are made LOW). This digital MUX selects either the value of the input channel (binary from the ADC) or the channel number (4-bit address from the channel counter). The selection is also controlled by the control logic that derives the control from the **EOM** signal from the EPROM.

The EPROM with 8-bit output stores the Morse code data in look-up-table form. Only one bit of the output is used to generate the Morse code and one more bit is used to generate the **EOM**.

The memory cell inside the EPROM is divided into two tables. The first table is the *Channel Value* table that has 256 rows. Each row represents a message in Morse, coded with binary bits. Each row is addressed by using 8 bit binary numbers. A key-up condition is coded as '0' and key down as '1'. One can encode Morse code like this and a dash can now be represented as 1110 and a dot can be represented as 10 and as a letter-space as 000. For example the first entry in this table represents the number *zero zero zero* and is coded as "11101110111011101110 0"

Morse digits 0~9 can be coded as shown in Table 1.

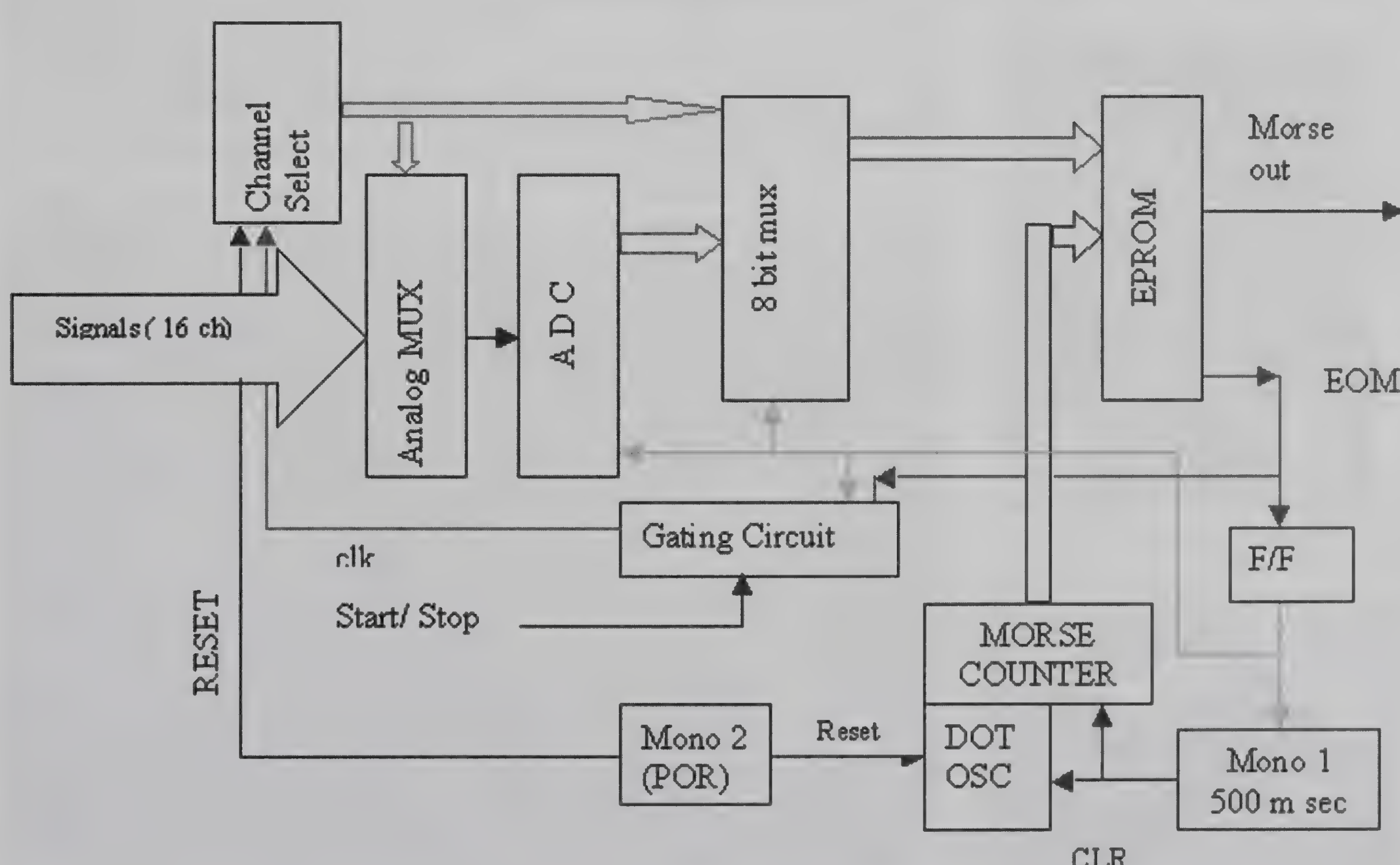


Figure 1. Block diagram of the beacon controller.

| Number | Code |
|---|---|
| 0 | 0111011101110111011100 |
| 1 | 01011101110111011100 |
| 2 | 010101110111011100 |
| 3 | 0101010111011100 |
| 4 | 01010101011100 |
| 5 | 010101010100 |
| 6 | 01110101010100 |
| 7 | 0111011101010100 |
| 8 | 011101110111010100 |
| 9 | 01110111011101110100 |

Table 1. Coding scheme for Morse equivalent of digits

| Address | Data bits D0 and D1 are only used |
|---|---|
| **Table 1: 256X64 bytes** | |
| 000000000000000 to 000000000011111 | First entry in table 1 |
| 000000010000000 to 000000010011111 | Second entry in table 1 |
| : : :     : : : | |
| 111111110000000 to 111111110111111 | Last entry in table 1 |
| **Table 2: 16X64 bytes** | |
| 000000001000000 to 000000001111111 | First entry in second table |
| : : :     : : : | |
| 00001111100000 to 00001111111111 | Last entry in table 2 |
| 00010000000000 to 11111111111111 | unused |

Table 2. Memory organization for the EPROM

Similarly Table 2 contains 16 rows and each row represents the channel number/ name encoded with bits as explained above.

If we want to transmit the Morse code for an input channel number/name, then Table 2 is selected and the channel address from 7493 is given as the address for Table 2 to select the wanted row of messages. Now the string of bits from this row is to be given out one-by-one sequentially. The counter IC CD4060 does this. This IC contains a multistage counter and an integrated oscillator. The counter is used as a 6 bit binary counter (counts from 0 to 63). The oscillator time period is selected equal to the dot period (about 120 Hz). So when this counter is enabled, it starts from its reset state of 000000 and counts upwards until it is reset. This Morse counter output forms the least 6 bits of the address to the EPROM. The seventh address bit of the EPROM is used to select the either the Table 1 (when this bit is zero) or the Table 2 (this bit is 1).

The EPROM memory is thus segmented to form two tables with 256 entries in the first and 16 entries in the second as shown below:

### EOM

An end of message (**EOM**) is available from the D1 bit of the EPROM. The EPROM bit D1 is programmed in such a way that this bit goes 'HIGH' at the next clock of the Morse counter after the end of every message. This bit is used to read the ADC and to select the next message to be played.

### Circuit Operation

The Power-on reset circuit resets the Channel counter and the Morse counter upon power on. IC U13A, a monostable multivibrator, generates a pulse to reset IC 7493 and IC 4060 at the time of power-on. Monostable chip U13B also resets the Morse counter for a few milliseconds so that the Morse counter now starts from '000000'. The JK flip-flop (U2A), wired as a toggle F/F, will also be initialized upon power up. The function of this F/F is to alternately select the Channel and its value to address the Morse through the 8-bit multiplexer circuit (U9 & U10). The message bits in Morse corresponding to the channel selected will be sent out bit-by-bit for every increase in counter IC 4060. This will be available at the D0 pin of EPROM. An EOM generated at the end of message will then toggle the F/F thus selecting the ADC output as the address of the next message to be played. The flip-flop operation also triggers the conversion of the ADC channel that was selected by the channel counter.

EOM triggers the monostable U13B and it in

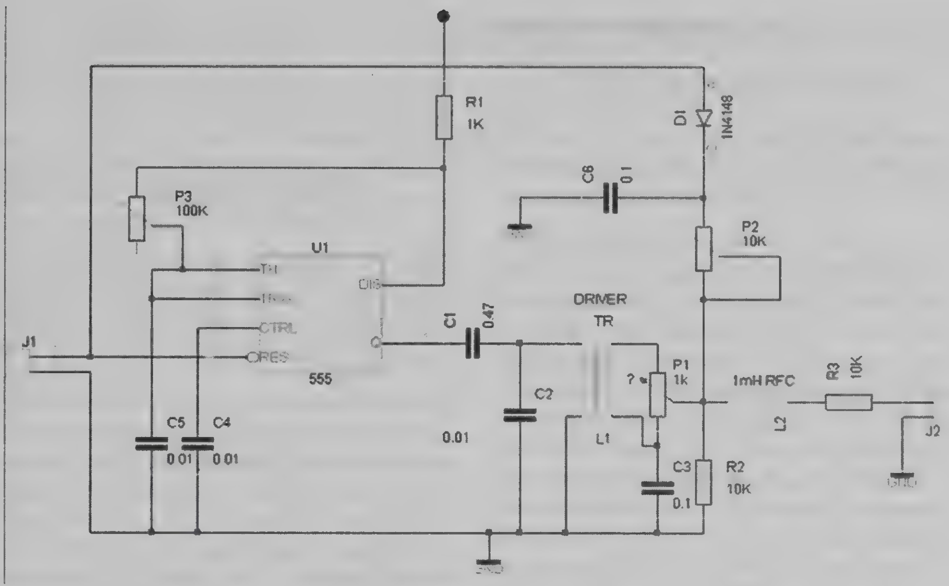


Figure 2. Modulator circuit

turn resets the Morse counter for a period approximately equal to the word-space. This action introduces a space of about one word-space before sending the next message. After this word-space the Morse counter restarts and sends out the Channel value read by the ADC. Again at the end of message, the channel counter gets a pulse advancing the channel counter to give the address to select the next channel data (voltage) for conversion. Analog multiplexing of the 16 such channels is achieved with the use of analog mux chips U4 and U6. The channel increment pulse also resets the Morse for a period of about a 4 word-space duration with the aid of another monostable circuit using IC U5B. The process repeats in cyclic mode enabling all the channels to be sent one-by-one until the stop button is pressed.

Message format is in the following form:

**<channel name><word space> <channel value>< 4 word space><next channel name><word space><channel value><4 word space>……..** and so on.

The circuit was wired and tested and is working fine with excellent Morse quality. The speed is set to around 10 words per minute.

It is possible to modify the Morse table so that we can change the channel name according to the actual parameter name to be telemetered. It is proposed by the AMSAT organizers that an identifying Morse signal must be added and the same can be easily incorporated by sacrificing the first channel.

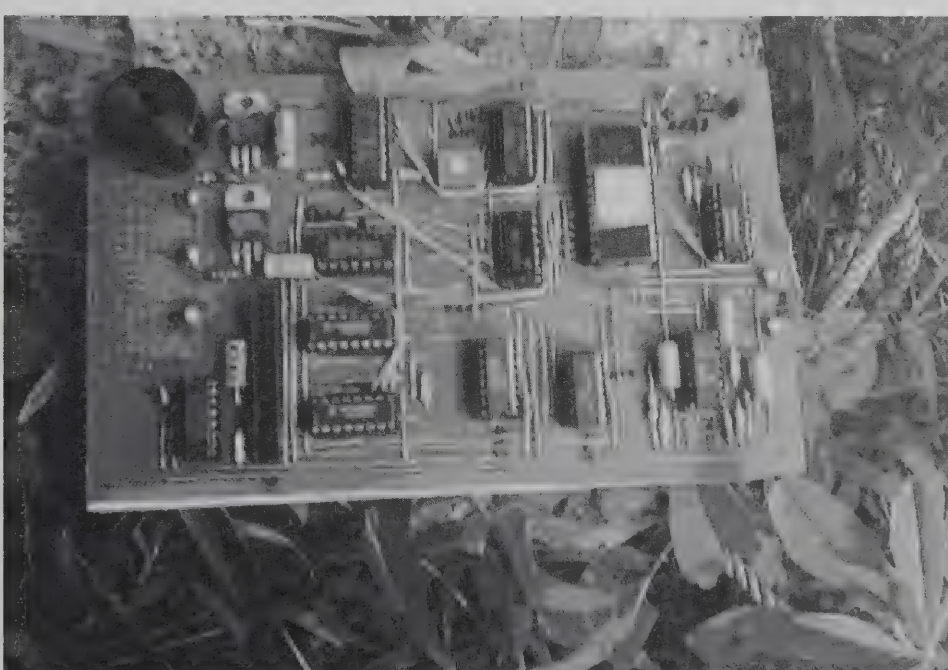

Figure 3. Prototype homebrewed by VU3WIH

Anyone who knows Morse code can easily decode and understand the parameters without the use of expensive equipment.

### Modulator

It is also proposed to use a special modulator so that the Morse signal can be copied using an FM receiver as well as a SSB receiver. The circuit diagram of such a modulator is as shown in Figure2.

The 555 timer IC is configured as an astable oscillator giving a square wave of 800 Hz. Using the frequency control potentiometer P3 can vary this frequency. This oscillator is keyed by the digital signal available from the EPROM (Morse Out). The square wave output is given to an audio coupling transformer and the output is taken through a level control potentiometer P1. Suitable wave shaping of the square wave to achieve good tonal quality is also done by the transformer with the aid of C2 and C1.

When the Morse Out goes HIGH, the 555 oscillator is enabled and it generates the audio tone. At the same time a potential divider arrangement using P2 and R2 applies a DC voltage derived from the logic-high level to the modulator. P2 is adjusted in such a way that the frequency shift due to this DC level applied across the modulating vari-cap diode is around 800 Hz. Now, if a SSB receiver is tuned to zero beat with the carrier, the keying causes a frequency shift of 800 Hz and a beat note is heard in the SSB receiver. So the message is readable with a SSB receiver. Whereas the tone voltage presented to the vari-cap also causes frequency modulation that can be demodulated using an FM receiver.

A prototype of the beacon controller was homebrewed and tested OK with excellent performance. Carrier generation and transmitter design will be done by Pratap Kumar, VU2POP and only then could we test the modulator and transmitter circuits.

### Acknowledgements

I was able to finish the project only because of the help and encouragement given to me by the AMSAT-INDIA, especially by its coordinator Nagesh Upadhyaya, VU2NUD. I am also indebted to OB Vinay, VU3WIH who helped me in assembling and testing the circuit. ■

# From The Dungeon: UoSAT2

## Allan Copland GM1SXX

Having just moved my home, actually *amalgamated* the contents of two homes into one, I was recently left in the situation of being bored out of my head because all my worldly goods were packed up in cardboard boxes while my new home looked rather like a building site. Well, it *was* a building site. Bored, because my usual pastimes of Amateur Radio, astronomy, and computers had been scuppered, temporarily at least by the house move, I was delighted to find my trusty little Hora C-150 handheld though while rummaging through some of the many cardboard boxes and so on a freezing (-8C) morning, a day or so before the New Year, stuck it in my jacket pocket in scan mode for company while I went out on a *recce* of the local DIY shop for various items I needed for the house.

Satellites were a million miles from my thoughts that morning as I slid around on the frozen pavements on the way to the shop. I had to concentrate hard just to remain upright. (My brain can only handle one thing at a time.) My walk took me over a rickety old metal footbridge spanning the main electrified railway line between Glasgow and the Clyde coast and as I climbed up the steps to the top of the bridge, my radio stopped scanning and burst into life. Di,di,dah,dah,dah,dah,dah,dah,dah. What sort of Morse is that? Not Morse code at all, but 1200 baud AFSK real-time telemetry data from UO-11/UoSat2, instantly recognizable once you have heard it a couple of times. The telemetry data are sent as a header line identifying the satellite as UO-11 and the date/time. Seven lines of encoded telemetry information follow the header block.

It sounds like *di,di,dah,dah, dah,dah,dah,dah,dah* for a complete telemetry block. Each block is transmitted as a data *frame* lasting 4.84 seconds. The satellite is capable of transmitting several data formats including the real-time telemetry blocks, whole orbit data (WOD) gleaned from a selection of onboard sensors, stored and then forwarded, plain text bulletins and some specialized formats. The real-time telemetry sounds like raspy Morse code in the format above while the plain text bulletin sounds rather like a noisy electric shaver being used!

UO-11 transmits data in response to an internal computer diary, pre-loaded by the ground controllers. The current transmitting schedule is:

- ASCII status (210 seconds)
- ASCII bulletin (60 seconds)
- BINARY SEU (Single Event Up sets) (30 seconds)
- ASCII TLM (Real-Time Telemetry blocks) (90 seconds)
- ASCII WOD (Whole Orbit data) (120 seconds)
- ASCII bulletin (Plain text bulletin) (60 seconds)
- BINARY ENG (Engineering Data) (30 seconds)

The ASCII bulletin is currently a static message, detailing modes and frequencies of all the Amateur Radio satellites. The schedule is transmitted as an endless loop.

I got interested in amateur satellites via this *bird* many years ago and it tickled me greatly that after more than seventeen years in orbit, it is still working. It is older in fact than some of the students at the college where I work. I had to smile when I realized that the satellite had broken the receiver squelch at a point when I was standing directly on top of a bridge with noisy 25,000 volt AC power cables running not a meter below my feet. The overhead lines carrying 25,000 volts made for a great light show when the trains went by. I can only describe the sound of the ice being vaporized by the pantographs on the carriages as being very similar to an electric-arc welding machine, only *far* more noisy and accompanied by a ferocious blue electrical discharge with ice fragments going in all directions. It's no exaggeration to say the sparks were flying that morning. The RFI caused was awesome yet there I was listening to UO-11 fly overhead. My Hora 2 meter handy has a tiny little stub antenna, all the more amazing that I was getting such solid copy.

```
start
20 minutes per count      Start Date 07/01/2002        from day No   7
ROTRACK  Magic Diamonds Tracking Chart for     Spacecraft UO-11
DAY  0  0  0  0  0  0  0  0  0  0  1  1  1  1  1  1  1  1  1  1  2  2  2  2
No.| 0  1  2  3  4  5  6  7  8  9  0  1  2  3  4  5  6  7  8  9  0  1  2  3
  7     FF   JE  M    H               H     M   CL   DH
  8      M BM   EH   F              C   FE  LC   N     H
  9    FB   KC   N   K  D         F      K     EJ    GG
 10      J  CK   FH   I               FC   M     N      K
 11       L    N  M    G                    I   FI    IF  IB
 12     D EI  HG  K   E           D   K    N      M     F
 13      I    M   M  CH                  G FG  KD  M
 14      FF   JE  M  H                   I     M  CL   DH
 15       M BM  EH   F            C  FE   LC    M    H
 16    FB KC  M   K     D          F   L   EJ      GG
 17      K  DK  GH   I               FC     M   N    K
 18      L      N  M     G               I     FI    IF      I
 19    D  EI    HG   K   E          D      K    M   M   F
 20     I     M    M     CH           G     FG   KD  M
 21    FF   JE   M     H               I       M  CL  DH
 22        M BM  EH   F           C  FE  LC    M     H
 23    FB   KC M      K   D        F   L      EJ    GG
 24      J  DK   GG    I               FC   M    N     K
Finished.
```

**Figure 1. UO-11 Orbit Passes from GM1SXX.**

For the newcomer to the world of satellites, this tough old bird still has a great deal to offer. All that's needed to decode the data from UO-11 is a simple 2m narrowband FM radio receiver, an old BBC microcomputer with a suitable program and an inquiring mind. In her 98-degree near-polar, retrograde orbit, the satellite overflies my home eight times daily. For anyone with some basic programming skills, there are a wealth of experiments to be done with the data transmitted by this satellite. Don't overlook the fun that can be had just analyzing the Whole Orbit Data and telemetry. When transmitting real-time-telemetry, the satellite transmits its ID and the time/date plus 60 channels of telemetry data and a string of *coded status flags*. One thing to note is that the spacecraft's real-time clock transmits the wrong time and date, a result of it being implemented in hardware (MSM5832 clock IC) and unable to be corrected by ground control.

Figure 1 shows a plot of UO-11's orbit as seen from my home QTH at 55.9 degrees North. The chart covers the 7-24 of January 2002 and was plotted with my DIY tracking program ROTRACK. The letters on the chart denote the amount of time in-range during each 20 minute timing slot with A= lousy and N = superb.

UO-11's near sun-synchronous orbit makes it ideal for school users, providing a batch of passes each morning followed by another batch of passes each afternoon. I'm sure that was probably intentional. The satellite was designed with the BBC Microcomputer in mind. When I first visited the University of Surrey's command center many years ago, I was amazed to find it lined wall-to-wall with BBC Micros. Although very inefficient compared to BPSK etc, the AFSK data format was a good choice when the *bird* was designed because almost all schools in the UK had a suitable computer with which to decode the transmitted data.

Many years ago, I wrote a simple BASIC program to capture the information onto floppy disk so that it could be played back once the pass finished. I gave away free copies to anyone who expressed the slightest interest. A year or two after that, I discovered our local university running a copy of my program to decode the telemetry data from UO-11's under the expert guidance of Alf, McCafferty, GM0PHM, a regular at the Surrey University colloquia. The University used a turnstile/reflector antenna on the flat roof of the physics department feeding an *ASTRID* dedicated satellite receiver.

Other sources of decoding software also exist and the reader is particularly encouraged to visit Clive Wallis' website where they will find various downloadable programs that can display the data transmitted by UoSAT2. Check out Clive's website at *http://www.users.zetnet.co.uk/clivew/oscar11.htm* for various audio files from UO-11 and downloadable software.

When I started decoding the data from UO-11 way back around 1985, I used a BBC computer and a simple terminal program that read the AFSK data from the satellite via the tape cassette port of the BBC Computer. I still do things that way. Fortunately, the BBC computer tape system also used 1200 bauds AFSK data format and so a couple of dozen lines of code to read the incoming data from the cassette circuitry and display it on the screen are all that's required for a simple data display system. Ideally, a hardware decoder such as the one designed many years ago by James Miller, G3RUH should be used, but I've always found the BBC computer cassette interface does an admirable job of extracting the data from the AFSK tones. The BBC computer, so heavily used by UK schools in the past is now long obsolete but in some ways, that can work to your advantage. They are now effectively junk and if you can find one (try asking the janitors of your local schools), owners are usually happy for you to take them away. Try to scrounge a floppy disk drive (or two) with some 5.25 inch floppies also (yes, they used to be that size in the good old days), because they can be used to hold working programs and captured data. The BBC computer can either drive a standard TV or preferably a dedicated composite video display monitor.

For BBC computer owners, the following short program written in a mix of BASIC and assembler many years ago by Trevor Stockhill, G4GPQ will display (but not decode) incoming telemetry blocks from UO-11 on your computer screen. All it does is to extract the data from the AFSK tones and display the results on screen.

If you own a 'BEEB' computer, try the following:

```
10 MODE3
20 ON ERROR GOTO 340
30 DIM CODE%100
40 FOR PASS% = 0 TO 2 STEP 2
50 P%=CODE%
60 [OPT PASS%
70 .start   JSR &FFE0
80          BCC chaok
90          CMP #&1B
100         BEQ error
110         JMP start
120.chaok   AND #&7F
130         CMP #&0D
140         BEQ print
150         CMP #&0A
160         BEQ exit
170         CMP #&1F
180         BPL print
190         LDA #&7C
200 .print  JSR &FFE3
210 .exit   JMP start
220 .error  LDA #&7E
230         JMP &FFE4
240 ]
250 NEXT PASS%
260 *FX205,64
270 *FX7,3
280 *FX156,3,252
290 *FX156,2,252
300 *M. 1
310 *FX2,1
320 *FX156,1,252
330 CALL start
340 *FX2,0
350 *M. 0
360 *FX156,2,252
370 *FX205,0
```

Note lines between 60-240 contain periods (.) and also lines 300 and 350 (*M.1) and (*M.0). The inline assembler code labels .start .print .exit .error and .chaok are preceded by a period. Anyone wishing a somewhat more sophisticated program to decode and display the telemetry data in a fully decoded form may contact me for a free copy. Send me an S.A.S.E. with a blank 5.25 inch floppy disk to: Allan Copland, Computer

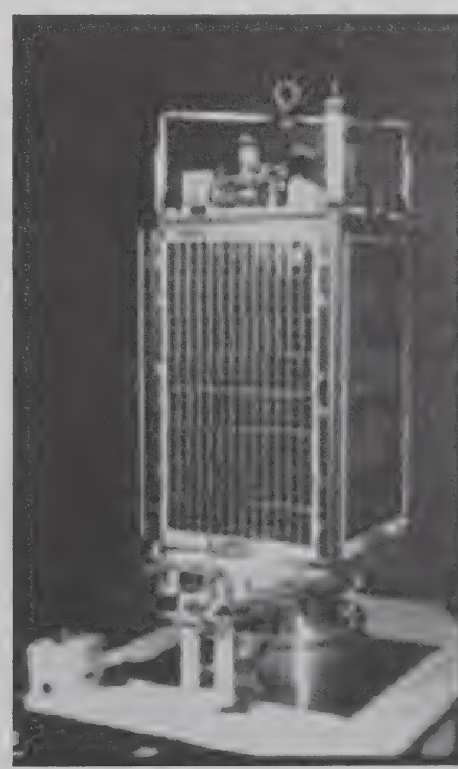
Figure 2. UO-11

Technicians, Reid Kerr College, Renfrew Road, Paisley, Renfrewshire, PA3 4DR and I'll send you a copy of the telemetry program ASAP.

At work, I have an old BBC micro connected to an ex PMR rig that takes the signals from UO-11 via a 7/8 wave vertical stuck out of our office window. This system works fine and cost about £30 total. The radio, an ex electricity board STORNO rig, was bought at a rally as scrap for £15, fitted with a new crystal for 145.826MHz and retuned.

If you live in the US and can't find a BBC micro, all is not lost. Some old MODEMS may also be suitable as an ASFK to ASCII decoder. You can use a Bell 202 standard MODEM with a 7404 inverter gate in the output lead to your PC's serial input port. A simple terminal emulator program will let you see the transmitted data on your PC or other computer. I have not personally tried this method, but I am assured it works ok. The emulation software should be set for 1200 bauds, 8 data bits and no parity. A more detailed description of decoding methods is beyond the limit of this article but interested parties are encouraged to visit Clive's pages at *http://www.users.zetnet.co.uk/clivew/uo11hw.zip* where you will find more information on hardware decoders including telephone modems.

The ideal antenna for use with UO-11 is a turnstile/ reflector fitted with a phasing harness to give left-hand circular polarization; ideal, but not essential, due to the good transmitted signal strength. A turnstile will give better signals when the satellite is near the horizon. Having said that, I've used all sorts of antennas with this bird from a crossed Yagi to *rubber ducks* antennas.

Although UO-11 was designed primarily as a research satellite and carries no amateur transponders, it is still a useful tool for beginners to amateur satellites. Providing as it does a very strong signal on 145.826MHz, it can demonstrate the effect of Doppler shift on an SSB receiver by tracking the carrier, while the telemetry data, especially the WOD (Whole Orbit Data) are interesting and fun to decode. For anyone with an interest in how Prof. Martin Sweeting and his team at the University of Surrey managed to construct such a hugely reliable and long-lived satellite (Figure 2), I would point you in the direction of a very detailed article that was published in the *Journal of the Institution of Electronic and Radio Engineers*. The ISSN is 0267-1689 and it was published as a supplement to the Sept/Oct 1987 of that journal. It is entitled *Supplement to Vol 57 No 5 Sept/Oct 1987*. It makes fascinating reading for the satellite enthusiast. I found a copy in the Mitchell Reference Library in Glasgow but anyone with a keen interest who cannot find a copy locally should contact me and I'll endeavor to post a copy to you ASAP. An SASE. (A4 Jiffy Bag or similar) with 4 first class stamps would be appreciated. The document runs to about 120 pages. I have half a dozen copies of this article to distribute. First come, first served.

UO-11 also carries beacons on 70cm and 13cm. The 70cm beacon is rarely used, except for telecommand purposes when in range of Surrey but the 13cm one makes a good signal source for testing receive gear for AO-40. Sample S-Band audio files are available in WAV format on Clive's Web Pages.

I hope this short article stimulates a little interest in this ancient and interesting research satellite. It still has much to offer the keen experimenter. I'm sure many commercial satellite operators would view its longevity of service with great envy. ■

# Applying Descriptive Statistical Analysis to SETI Data

## *Looking for the Abnormal in the Normal*

**Russ Tillman, K5NRK**

This article discusses basic descriptive statistical analysis techniques that are useful to satellite designers and operators as well as searchers for extraterrestrial intelligence (SETI). To show the value of descriptive statistics, analysis of SETI@Home data is performed and presented to describe *normal data* as well as data that *fall outside of the norm*. Understanding how to describe *normal* and *abnormal* situations for large data sets may prove valuable to Amateur Radio operators that may need to quantify, understand, modify, and enhance certain amateur satellite situations.

### How Do We Describe Data?

The advent of the digital age has provided our world with easily generated, readily available, and exchangeable *data*. For example, from a radio amateur shack, we can now easily convert analog signals to digital signals (or vice versa), store them on a hard drive, and send them (telemetry) to a friend for later analysis. Given the tremendous amount of data available, challenges exist not only to manage (or avoid) *data overload*, but to understand the value of these extremely large data sets in hopes that it will allow us to do something better. The use of basic descriptive statistic techniques is a first step in accomplishing this task as it attempts to *describe* the center of a data set (measurements of central tendencies, or *averages)*, how data are spread (measurements of dispersions, or *deviation)* around the center, and whether the data are *normal*. Knowing the center and spread of your data is very valuable, and can even be used to make inferences about other things. (And, that's called *inferential statistics* and something we will avoid in this article!) So without trying to present a semester course in statistics, let's first briefly discuss two ways to describe the center data, measures of dispersion, and normality:

• **Mean:** The mean is calculated by adding up the values of your data and dividing by the number of observations. The mean is commonly used in everyday life; an example is finding the average age of AMSAT members by adding up each member's age and dividing by the total number of members.

• **Median:** The median is the *middle* value once the data set has been arranged in order of its values. The median is a value that is halfway between the number of observations [(n+1)/2]. That is, half of the data (n) lies above and the other half lies below. Calculating the median is a bit more difficult than the mean, as you have to arrange the data in ascending or descending order. For example, to find the median age of AMSAT members, you would sort all members by age (either ascending or descending order). Then you would divide the number of members (n+1) by two and find where that value lies on your list of member's ages. Sometimes, the median tends to be a better measurement of the center such as when you have *outliers* that can *skew* your mean. For example, the mean of the following ages 22, 23, 23, 24, 96 is **37** while the median is **23**. With the value **96,** seeming to be an *outlier*, what is the best measurement of center?

OK, let's trudge through the remaining half of our Statistics 101 tutorial and then move on to the fun part of the article. That is, how do we measure dispersion, or how data are *spread around the center*, and what are *normal* data?

• **Measurements of Dispersion:** While there are many measurements of dispersion (range, mean absolute deviation, and variance), let's just focus on the standard deviation as it provides the most value for our upcoming analysis. Defined without showing its complex formula, standard deviation is simply a number that is used to describe the dispersion of data around its center.

• **Normality:** Since a picture speaks a thousand words, let's show the dispersion of data on a *frequency distribution* (graph) with *frequency* of observations on the y-axis and the range of values *distributed* on the x-axis (Figure 1). When you identify the mean (center) of this graph, you will observe that values will tend to *cluster* around the mean. Also your data will take a *normal* shape that represents a *bell curve* with half of the data lying on either side of the mean. Interestingly, most things occurring in nature (i.e. physical, biological, and social) are approximately *normally distributed around the mean.* (e.g. runs scored in baseball games or scores on Amateur Radio license examinations.) For example, the *average* wave height at Pensacola Beach, Florida, is about 2 feet and is normally distributed around the mean with a standard deviation of 0.25 feet. As a result, there are very few (calm) days you will see no waves at all, or for that matter very few days in which waves will be 6 feet or higher (hurricanes). Rather, wave heights tend to be closely distributed around the

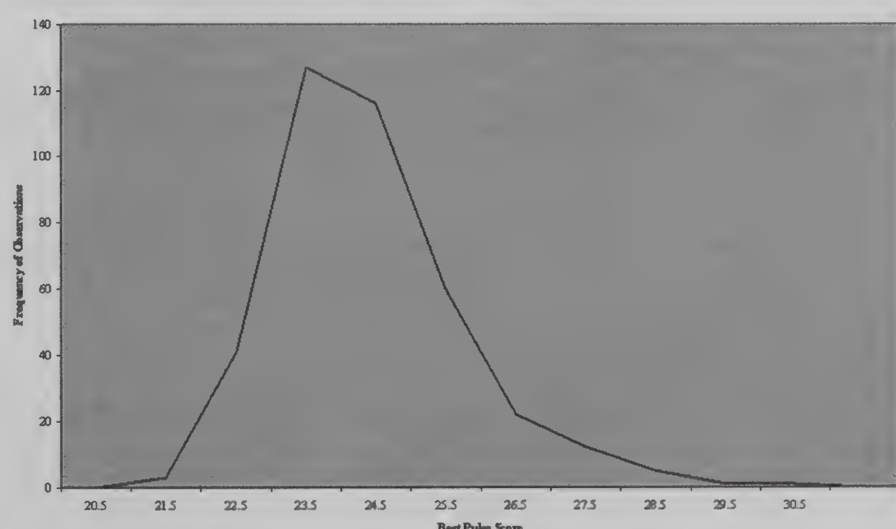


**Figure 1. A Frequency Distribution of SETI@Home Best Spikes Analyzed by K5NRK. Note that the shape of this distribution approximates normality and as a result, represents a bell-shaped curve with the mean located in the center (24.62). Observations *lying on the edge* of this distribution and outside of 3 standard deviation units from the mean (<14.45 to 34.80>) are a cause of interest and should be considered for future investigation.**

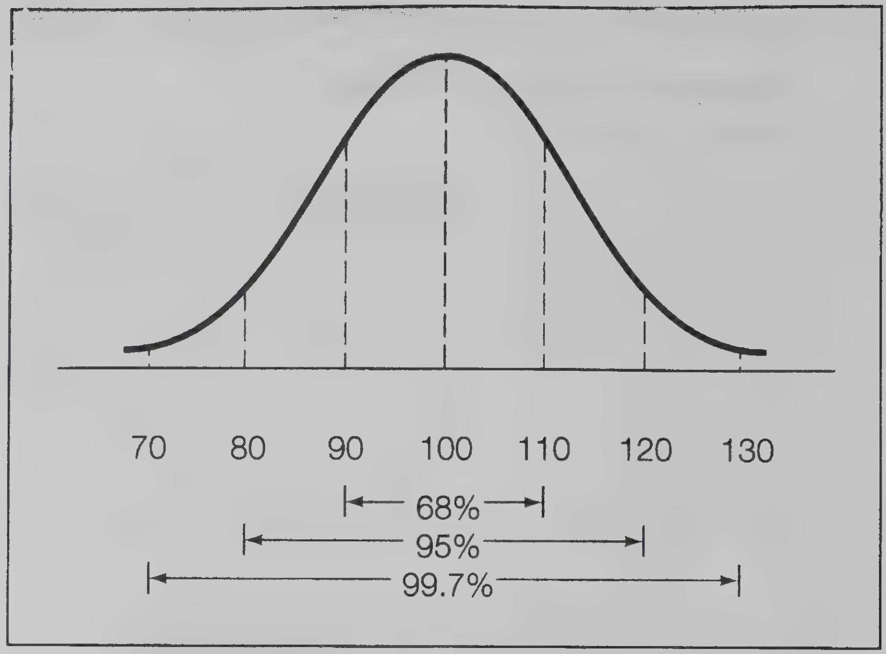


**Figure 2. Normal Distribution of Data Around the Mean. In a normal distribution, 68 percent of all observations fall within 1 standard deviation unit from the mean, 95 percent within 2 standard deviation units, and 99.7 percent within three standard deviation units.**

mean of 2 feet.

• **Standard Deviation and Normal Curves:** Pafnuty Lvovich Chebyshev was a 19th century mathematician who used his understanding of data that were *normally distributed around the mean* to develop the Empirical Rule. This rule states that when data are normally distributed around the mean, 68 percent of all data will be within one standard deviation units from the mean, 95 percent will be within two standard deviation unit, and 99.7 percent (nearly all) of data will be within three standard deviation units from the mean (Figure 2). So, if you get a value that is beyond three standard deviation units from the mean, it is a red flag that merits further investigation. We can also measure deviation using a *z score* that indicates how far and in what direction an item deviates from its distribution's mean as expressed in units of its distribution's standard deviation (i.e. 2.385 standard deviation units from the mean). Z-score is calculated by subtracting an observation from the mean and then dividing it by the standard deviation.

• **Measuring Normality:** Karl Pearson, a 20th century statistician developed the following numerical coefficient to describe how normal data are: [3*(mean-median)]/standard deviation]. When using this coefficient, you usually get a score between –3 (negatively skewed) and +3 (positively skewed) with a score of 0 meaning your data are perfectly normal (Figure 3).

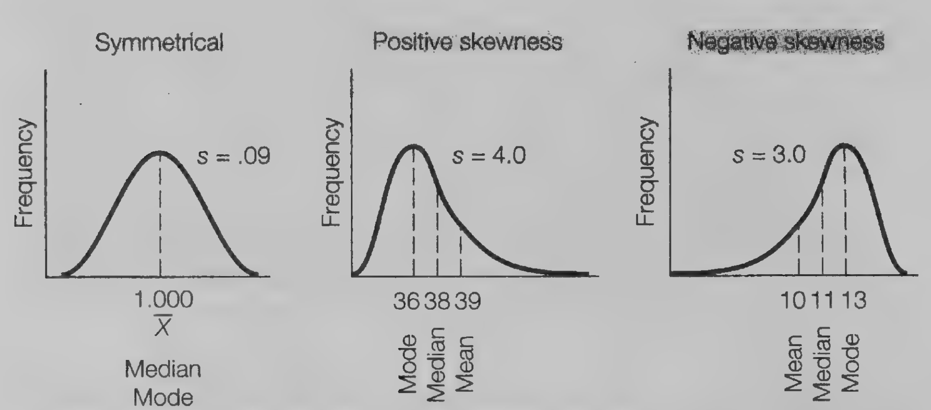


**Figure 3. Normal and Skewed Data. As shown in this figure, data described by frequency distributions can be normal, or positively or negatively skewed. Pearson's coefficient of skewness, allows us to express the extent of normality or skewness with a number.**

In summary, our crash descriptive statistics course has taught us some of the ways to describe the center, spread, and normality of data. We also learned that data tends to cluster around the center. However, before applying these calculations to SETI data, let's briefly discuss The SETI League and SETI@Home.

### The SETI League

Many AMSAT members are active in SETI, including participation in The SETI League and SETI@Home that use unique strategies in the search for extraterrestrial intelligence. The SETI League membership is predominately made up of Amateur Radio operators whose capabilities are employed in providing innovative real-time sky search for SETI signals.[1] Thus, The SETI League has concentrated its efforts on devising a global network of thousands of participating stations. This endeavor is called *Project Argus,* and it is the basis for achieving the SETI League's goal of providing full sky coverage. The following write-up, taken from *Tune in the Universe: A Radio Amateur's Guide to the Search for Extraterrestrial Intelligence*[1c], provides a good justification for employing descriptive statistical analysis to identify candidate SETI signals for further examination and verification[2]:

*Based upon the beamwidths typical of Amateur Radio telescopes, scanning all four pi steradians of sky in real time will require something on the order of 5,000 participants. This goal seems elusive, when viewed from our present perspective of 24 active stations (as of December 1996). But The SETI League is adopting a longer view. If we provide the necessary coordination between participant stations, we can hope to achieve full sky coverage early in the next decade.*

*The search space for SETI involves temporal, directional, and frequency dimensions, and it's probably unrealistic to expect any search to encompass all possibilities. Nevertheless, the greater the number of participants, the more frequencies and directions we can hope to monitor per unit time. The publication of these pages constitutes a part of that effort. But an infinite network will avail us little if all members end up searching on the same frequency, in the same direction, at the same time.*

*There are good arguments against dictating frequency coverage at present. Sky coverage, on the other hand, can be readily coordinated. A major concern of SETI professionals is whether Amateur Radio astronomers have the training and discipline to separate the electromagnetic wheat from the cosmic chaff. That is, will we be fooled by astrophysical phenomena and manmade interference which might masquerade as intelligently generated extraterrestrial signals? The concern is a valid one; even professionals are sometimes fooled by their equipment or the environment. When Frank Drake first swung his Project Ozma dish toward Epsilon Eridani, he was excited to be greeted by a strong, stable, clearly artificial signal. "Can it really be this easy?" he wondered. It took five days of repeat observations for Drake to figure out that he was being tantalized by manmade interference, most likely from a high-flying military aircraft.*

### SETI@Home

SETI@Home is operated by the University of California, Berkeley SETI team who via the Internet, innovatively *borrows* private world-wide excess PC computational power to analyze data that have been generated from their radio astronomy search for extraterrestrial signals[3]. Currently, over 3.4 million persons have participated in SETI@Home providing computational analysis on over 424 million packets of data. Analysis of SETI data has also become competitive; Tom Clark, W3IWI is founder of the AMSAT SETI@Home team which has 140 participants who have impressively processed over 230,000 packets. While a relatively small-sized team, their innovation has placed them at 102nd in SETI@Home team competition.[4] In fact, at the 2001 AMSAT symposium, W3IWI gave an impromptu and fascinating talk on AMSAT's innovative involvement in SETI@Home that served as inspiration for this data analysis and subsequent article.[5]

Included in W3IWI's talk were ways to enhance speed when computing SETI data including the use of *SETISpy*, a utility software add-on that observes and records your SETI@Home progress.[6] Among many things, *SETISpy* keeps a log that summarizes the computation analysis (Table 1), including:

- **Date Done:** Date the SETI@Home participant competed the packet.
- **Time Done:** Time SETI@Home participant completed the packet.
- **Work Unit Name:** SETI@Home classification of data packet that contains date data were collected.
- **Start RA:** Beginning Right Ascension location of data collection.
- **Start DEC:** Beginning Declination location of data collection.
- **Angle Range:** The path of a SETI sky survey in relationship east to west survey at zenith.
- **TeraFLOPs:** Trillions of floating point operations required to process a packet.
- **Process Time:** Amount of time required by SETI@Home user to process a packet.
- **Percent Done:** Amount of packet processed by SETI@Home user.
- **Returned Spikes*:** Spikes are radio signals occurring at single frequencies that are strong enough to be distinguished from general noise.[7]
- **Best Spike*:** Best spike score from respective data packet.
- **Returned Gaussians*:** Signals from a distant transmitter should get stronger and then weaker as the telescope's focal point moves across that area of the sky. Specifically, the power should increase and then decrease with a bell-shaped Gaussian curve (Figure 4). Gaussian curve-fitting is an excellent test to determine if a signal is *out there* rather than a simple source of interference somewhere here on Earth, since signals originating from Earth will typically show constant power patterns rather than curves. The Gaussian test is only applied for frequency resolutions greater than or equal to 0.59 Hz.[7]
- **Best Gaussian*:** Best Guassian score from the respective data packet.
- **Returned Pulses*:** Our alien neighbors may not be sending out a nice, even tone for us to

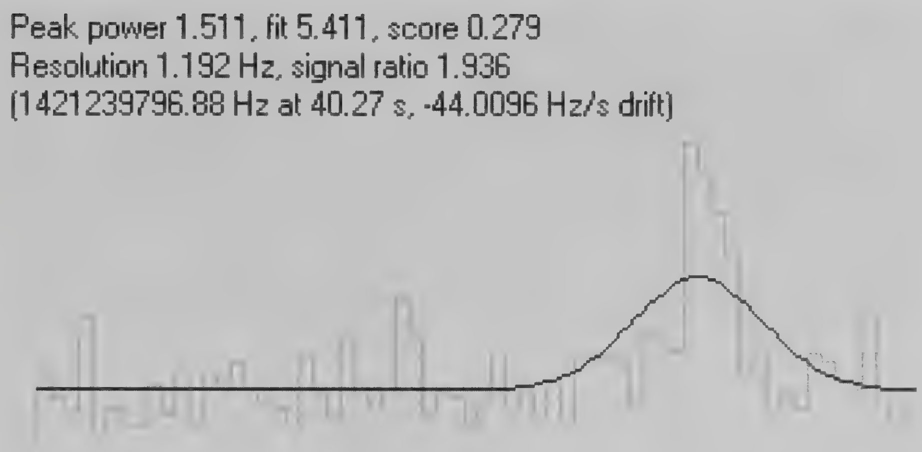


**Figure 4. Example of Gaussian curve fit to a SETI@Home collected signal.**


**Figure 5. Example of a spike from a SETI@Home collected signal.**

| Date Done | Time Done | Work Unit Name | Start RA | Start Dec | Angle Range | Tera-FLOPs | Process Time-hr | Percent Done | Returned Spikes | Best Spike | Returned Gauss'ns | Best Gauss'n | Returned Pulses | Best Pulse | Returned Triplets | Best Triplet |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 9-Oct-01 | 2:11:03 | 05fe01aa.26718.17313.717330.163 | 20.412 | 18.01 | 0.417 | 4.108 | 10.009 | 100.00% | 1 | 24.404 | 0 | 1.135 | 3 | 1.086 | 1 | 9.125 |
| 9-Oct-01 | 3:55:05 | 08ja01ab.15046.1986.348568.9 | 6.917 | 28.4 | 0.386 | 4.142 | 10.932 | 100.00% | 10 | 24.092 | 0 | 1.422 | 3 | 1.046 | 0 | 0 |
| 9-Oct-01 | 4:10:29 | 09fe01ab.20205.3634.436076.49 | 6.354 | 13.86 | 0.492 | 4.031 | 9.808 | 99.90% | 7 | 28.9 | 0 | 1.755 | 1 | 1.006 | 0 | 0 |
| 9-Oct-01 | 11:02:17 | 17fe01ab.12355.12512.559668.111 | 10.064 | 15.22 | 0.485 | 4.041 | 43.845 | 100.00% | 6 | 24.221 | 0 | 2.149 | 1 | 1.001 | 2 | 8.955 |
| 9-Oct-01 | 13:05:49 | 17fe01ab.12355.26242.479830.38 | 15.273 | 0.8 | 0.03 | 3.543 | 9.171 | 100.00% | 8 | 22.767 | 0 | 0 | 1 | 1.03 | 4 | 10.44 |
| 9-Oct-01 | 23:29:54 | 05fe01aa.26718.24242.761084.36 | 23.704 | 20.15 | 0.412 | 4.113 | 12.455 | 100.00% | 1 | 21.882 | 0 | 2.498 | 0 | 0.979 | 0 | 0 |
| 10-Oct-01 | 0:08:52 | 09fe01ab.8623.14050.342332.90 | 10.262 | 9.2 | 0.559 | 3.98 | 10.821 | 100.00% | 8 | 23.007 | 2 | 3.22 | 1 | 1.046 | 0 | 0 |
| 10-Oct-01 | 4:11:37 | 17fe01ab.12355.17346.486066.107 | 12.316 | 10.8 | 0.033 | 3.544 | 9.883 | 100.00% | 6 | 23.204 | 0 | 0 | 3 | 1.053 | 3 | 12.922 |
| 10-Oct-01 | 9:02:59 | 17fe01ab.12355.23986.436076.35 | 15.352 | 0.83 | 0.029 | 3.543 | 8.894 | 100.00% | 3 | 23.173 | 0 | 0 | 3 | 1.014 | 3 | 9.253 |
| 10-Oct-01 | 11:25:39 | 04mr01ab.3241.17376.284650.97 | 16.609 | 8.12 | 0.681 | 3.897 | 11.928 | 100.00% | 6 | 24.419 | 1 | 1.244 | 1 | 1.027 | 1 | 8.055 |

**Table 1. Example of data output from *SETISpy* log.**

detect. They may be sending a series of spaced pulses—a more economical use of power. For all frequency resolutions greater than or equal to 0.59 Hz, the SETI@home screensaver searches for repeating pulses (Figure 5) and spike triplets.[7]

- **Best Pulse*:** Best pulse score for respective data packet.
- **Returned Triplets*:** A triplet is a set of three equally spaced spikes. Because triplets are evenly spaced, they are considered as possible SETI signal candidates. The SETI@home screensaver tests for triplets by looking at every pair of spikes above a certain threshold power. It then looks for another spike precisely between the two spikes. If one is found, a triplet is logged and sent back to Berkeley.[7]
- **Best Triplet*:** Best triplet score from respective data packet.

It is the data generated from this log (namely the last eight items that are marked with an asterisk) that we will apply to the basic descriptive statistic measurements from our earlier discussion. It is from this descriptive analysis that we can determine potential candidate SETI signals for future examination and analysis by identifying SETI signals *that are out of the norm.* Using descriptive statistical analysis as a start, these candidate or outlier signals warrant further examination that can reveal whether the signal is the result of a flaw in the data collection or analysis (such as random error) or the need to re-survey that portion of the sky to see if the same results are obtained.

### Results of SETI@Home Data Analysis

Using a summary log (Table 1) generated by *SETISpy*, a descriptive statistical analysis was made on the results of 407 SETI@Home packets that were collected by your author. The results of this analysis are summarized as Table 2 and provide the mean, median, standard deviation, significant value, and Pearson's coefficient of skewness for SETI@Home spikes, Gaussian curve strengths, pulses, and triplets. It is the *significant value* calculation from this analysis that is of interest as it provides the value that is three standard deviation units from the mean. Assuming these data are normal, 99.7 percent of all observations should fall within three standard deviation units from the norm.

From these descriptive measures, 25 candidate packets are identified *that do not fall*

| | Returned Spikes | Best Spike | Returned Gauss'ns | Best Gauss'n | Returned Pulses | Best Pulse | Returned Triplets | Best Triplet |
|---|---|---|---|---|---|---|---|---|
| **Mean** | 10.1 | 24.62 | 0.61 | 1.7 | 1.08 | 1.01 | 0.77 | 3.85 |
| **Median** | 9 | 24.15 | 0 | 1.59 | 1 | 1.01 | 0 | 0 |
| **Standard Deviation** | 13.55 | 3.39 | 1.75 | 1.18 | 1.56 | 0.1 | 1.16 | 4.72 |
| **Significant Value (at 3 standard deviation units)** | 50.77 | 34.8 | 5.86 | 5.23 | 5.77 | 1.31 | 4.24 | 18.02 |
| **Pearson's Measurement of Skewness** | 0.24 | 0.42 | 1.04 | 0.28 | 0.15 | 0.2 | 2 | 2.44 |
| **Candidate Signals** | 3 | 3 | 16 | 0 | 6 | 2 | 2 | 0 |
| **Estimated Candidates per 100** | 0.74 | 0.74 | 3.93 | 0 | 1.47 | 0.49 | 0.49 | 0 |

**Table 2. Measures of central tendencies and dispersion for 407 SETI@Home observations taken from K5NRK *SETIspy* log.**

| Date Done | Time Done | Work Unit Name | Returned Spikes | Best Spike | Returned Gauss'ns | Best Gauss'n | Returned Pulses | Best Pulse | Returned Triplets | Best Triplet |
|---|---|---|---|---|---|---|---|---|---|---|
| 22-Oct-01 | 10:49:57 | 06ja01aa.28699.15698.417318.128 | 192 | 71.53 | 0 | 1.269 | 2 | 1.016 | 0 | 0 |
| **25-Dec-01** | **7:00:06** | **17my01ab.14901.25568.978394.51** | **175** | **62.59** | **0** | **1.125** | **9** | **1.47** | **0** | **0** |
| 1-Nov-01 | 6:44:20 | 14mr01ab.6412.7824.640914.102 | 148 | 36.17 | 0 | 0 | 0 | 0.916 | 0 | 0 |
| 22-Dec-01 | 7:06:25 | 28ap01ab.7341.18961.786080.0 | 78 | 28.263 | 3 | 3.367 | 0 | 0.995 | 2 | 9.279 |
| 12-Oct-01 | 8:35:53 | 07mr01aa.10472.3905.642322.55 | 7 | 24.345 | 12 | 4.106 | 0 | 0.991 | 0 | 0 |
| 26-Dec-01 | 2:18:41 | 17my01aa.6778.33552.1015912.156 | 4 | 23.547 | 11 | 4.166 | 1 | 1.031 | 0 | 0 |
| 19-Oct-01 | 7:17:24 | 11fe01ab.10790.18896.197168.137 | 16 | 30.007 | 10 | 3.64 | 0 | 0.983 | 1 | 8.983 |
| 14-Nov-01 | 7:00:45 | 30ja01aa.14930.25936.534648.34 | 9 | 25.318 | 10 | 3.431 | 0 | 0.982 | 1 | 8.723 |
| 2-Dec-01 | 2:07:50 | 28fe01aa.24428.18768.28414.229 | 6 | 24.583 | 9 | 4.24 | 0 | 0.992 | 0 | 0 |
| 14-Oct-01 | 1:55:50 | 04mr01ab.3241.20273.42344.203 | 10 | 24.354 | 8 | 5.135 | 1 | 1.056 | 0 | 0 |
| 7-Dec-01 | 5:12:50 | 12mr01ab.1918.1122.79836.61 | 3 | 23.794 | 8 | 4.954 | 1 | 1.149 | 0 | 0 |
| 2-Dec-01 | 13:33:16 | 28fe01aa.24428.25840.128420.111 | 13 | 24.048 | 7 | 3.426 | 0 | 0.964 | 2 | 9.162 |
| 26-Oct-01 | 1:09:52 | 06ja01aa.28699.33153.642322.108 | 13 | 23.073 | 7 | 3.995 | 1 | 1.023 | 2 | 9.772 |
| 16-Oct-01 | 13:21:51 | 09fe01ab.8623.20258.154822.165 | 7 | 23.691 | 7 | 3.817 | 1 | 1.073 | 0 | 0 |
| 31-Oct-01 | 1:19:50 | 04mr01aa.18950.12640.703400.148 | 7 | 23.363 | 7 | 4.444 | 0 | 0.954 | 0 | 0 |
| 21-Nov-01 | 12:44:50 | 07ja01aa.5693.16610.354830.252 | 7 | 23.17 | 7 | 3.826 | 0 | 0.973 | 0 | 0 |
| 17-Nov-01 | 8:37:18 | 11mr01aa.769.18624.1034646.145 | 3 | 23.52 | 7 | 3.792 | 2 | 1.03 | 1 | 10.998 |
| 6-Nov-01 | 13:01:04 | 11mr01aa.769.11776.422146.110 | 13 | 27.062 | 6 | 3.796 | 0 | 0.968 | 3 | 9.492 |
| 6-Nov-01 | 1:58:08 | 30ja01aa.14930.30448.603396.80 | 8 | 24.835 | 6 | 3.826 | 0 | 0.975 | 0 | 0 |
| 11-Dec-01 | 7:27:38 | 18mr01ab.11466.22338.373564.98 | 5 | 22.833 | 6 | 3.578 | 0 | 0.997 | 0 | 0 |
| 1-Dec-01 | 7:20:31 | 01fe01aa.21320.11090.997154.66 | 13 | 25.927 | 2 | 3.377 | 19 | 2.22 | 2 | 9.336 |
| 1-Dec-01 | 2:20:46 | 02mr01ab.9821.19474.367328.92 | 5 | 24.75 | 1 | 1.119 | 6 | 1.235 | 0 | 0 |
| 25-Dec-01 | 12:56:20 | 06ap01ab.471.22001.623562.168 | 13 | 24.086 | 0 | 2.147 | 6 | 1.184 | 0 | 0 |
| 18-Oct-01 | 4:26:10 | 17fe01ab.12355.23697.354830.88 | 12 | 23.417 | 0 | 0 | 6 | 1.069 | 5 | 9.533 |
| 21-Oct-01 | 11:04:29 | 26fe01ab.13959.16064.1022148.113 | 11 | 24.623 | 0 | 0 | 7 | 1.151 | 6 | 10.501 |

**Table 3. Identification of Candidate SETI Signals. Of the 407 SETI@Home data packets analyzed, 25 packets contained values that were greater than 3 standard deviation units from the mean (shaded). Note some candidates, such as 17my01ab.14901.25568.978394.51, have more than 1 value that is greater than 3 standard deviation units from the mean that may make it a *stronger* candidate for further investigation.**

*within the norm* (i.e. outside of three standard deviation units from the mean) for spikes, Gaussians, pluses, and triplets (Table 3). These candidate packets, called *outliers* may be caused by a variety of things; the result of random error in the sensitivity of the data collection equipment, study methodology, sky noise from terrestrial or celestial objects, or may be actual leads for SETI signals. Of the 25 candidates identified in Table 3, 17my01ab.14901.25568.978394.51 appears to be the strongest candidate with outliers in four of the eight categories.

To better quantify our data, Z-scores for each outlying candidates is provided as Table 4. Remember, a Z-score measures the distance of the observation from the mean in standard deviation units of our sample (and is abbreviated using the Greek term sigma, or s). From this analysis of Best Spikes, we observe that work unit 06ja01aa.2899.15698.417318.128 is the farthest from the mean with a z-score of 13.83s. Referring to our calculation of *Estimated Candidates per 100* (Table 2), one Best Spike event will occur outside three standard deviation units 0.74 times per 100 packets. However, when dealing with the existing 424,000,000 SETI@Home data packets, this would result in 3,137,600 data packets with Best Spikes lying outside of the norm. For the time being, that is too many data sets to follow up on! As a result to *manage* the volume of candidate signals, most SETI programs set their *decision rule* for further analysis as candidate signals at 5s or 6s units, while SERENDIP has a decision rule of 20s[8]. As a reference point, the famous Ohio State University *WOW* signal was measured at 30s from the mean[9].

So given this data overload, what is a poor Amateur Scientist to do? There is value in knowledge. Monitoring, examining, and analyzing a sample of outlying candidate signals may provide a list of characteristics that are *normal* for outliers. That is, understand the reasons why candidate signals can fall outside of the norm. This list could then be used to screen out, or promote the value of future candidates.

## Limitation and Value of SETI@Home Analysis

It is very important to note that these candidate signals do not provide proof that *ET is calling*, rather they are simply a starting point that provides direction for more detailed analysis and examination. Included in this analysis could be attempts by SETI League members, and their AMSAT cousins to replicate the data by resurveying the same area of the sky. It is from this further analysis that a better understanding of *what to do next* emerges. That is, descriptive statistics simply provide a preliminary investigation that may lead to a new hypothesis, or future direction for further examination or verification.

Readers should be aware that this is a very elementary analysis when compared to other SETI endeavors. As a result, several limitations are identified with this analysis, namely:

a. **Number of Packets Analyzed:** These results only represent descriptive statistical analysis on 0.00000096% (407/424,000,000) of all SETI@Home data packets (Figure 6). (And for that matter, how much does these 424,000,000 SETI@Home data packets represent Earth's SETI observation opportunities? Unfortunately this sample is greatly smaller than our 0.00000096% sample!) While

| Date Done | Time Done | Work Unit Name | Returned Spikes | Best Spike | Returned Gauss'ns | Best Gauss'n | Returned Pulses | Best Pulse | Returned Triplets | Best Triplet |
|---|---|---|---|---|---|---|---|---|---|---|
| **22-Oct-01** | **10:49:57** | **06ja01aa.28699.15698.417318.128** | **13.42** | **13.83** | **-0.35** | **-0.36** | **0.59** | **0.02** | **-0.67** | **-0.81** |
| 25-Dec-01 | 7:00:06 | 17my01ab.14901.25568.978394.51 | **12.17** | **11.19** | -0.35 | -0.49 | 5.07 | 4.57 | -0.67 | -0.81 |
| 1-Nov-01 | 6:44:20 | 14mr01ab.6412.7824.640914.102 | **10.17** | **3.4** | -0.35 | -1.44 | -0.69 | -0.99 | -0.67 | -0.81 |
| 22-Dec-01 | 7:06:25 | 28ap01ab.7341.18961.786080.0 | 5.01 | 1.07 | 1.37 | 1.42 | -0.69 | -0.2 | 1.06 | 1.15 |
| 12-Oct-01 | 8:35:53 | 07mr01aa.10472.3905.642322.55 | -0.23 | -0.08 | **6.51** | 2.05 | -0.69 | -0.24 | -0.67 | -0.81 |
| 26-Dec-01 | 2:18:41 | 17my01aa.6778.33552.1015912.156 | -0.45 | -0.32 | **5.94** | 2.1 | -0.05 | 0.17 | -0.67 | -0.81 |
| 19-Oct-01 | 7:17:24 | 11fe01ab.10790.18896.197168.137 | 0.43 | 1.59 | **5.36** | 1.65 | -0.69 | -0.32 | 0.2 | 1.09 |
| 14-Nov-01 | 7:00:45 | 30ja01aa.14930.25936.534648.34 | -0.08 | 0.21 | **5.36** | 1.47 | -0.69 | -0.33 | 0.2 | 1.03 |
| 2-Dec-01 | 2:07:50 | 28fe01aa.24428.18768.28414.229 | -0.3 | -0.01 | **4.79** | 2.16 | -0.69 | -0.23 | -0.67 | -0.81 |
| 14-Oct-01 | 1:55:50 | 04mr01ab.3241.20273.42344.203 | -0.01 | -0.08 | **4.22** | 2.92 | -0.05 | 0.42 | -0.67 | -0.81 |
| 7-Dec-01 | 5:12:50 | 12mr01ab.1918.1122.79836.61 | -0.52 | -0.24 | **4.22** | 2.77 | -0.05 | 1.36 | -0.67 | -0.81 |
| 2-Dec-01 | 13:33:16 | 28fe01aa.24428.25840.128420.111 | 0.21 | -0.17 | **3.65** | 1.47 | -0.69 | -0.51 | 1.06 | 1.12 |
| 26-Oct-01 | 1:09:52 | 06ja01aa.28699.33153.642322.108 | 0.21 | -0.46 | **3.65** | 1.95 | -0.05 | 0.09 | 1.06 | 1.25 |
| 16-Oct-01 | 13:21:51 | 09fe01ab.8623.20258.154822.165 | -0.23 | -0.27 | **3.65** | 1.8 | -0.05 | 0.59 | -0.67 | -0.81 |
| 31-Oct-01 | 1:19:50 | 04mr01aa.18950.12640.703400.148 | -0.23 | -0.37 | **3.65** | 2.33 | -0.69 | -0.61 | -0.67 | -0.81 |
| 21-Nov-01 | 12:44:50 | 07ja01aa.5693.16610.354830.252 | -0.23 | -0.43 | **3.65** | 1.81 | -0.69 | -0.42 | -0.67 | -0.81 |
| 17-Nov-01 | 8:37:18 | 11mr01aa.769.18624.1034646.145 | -0.52 | -0.33 | **3.65** | 1.78 | 0.59 | 0.16 | 0.2 | 1.51 |
| 6-Nov-01 | 13:01:04 | 11mr01aa.769.11776.422146.110 | 0.21 | 0.72 | **3.08** | 1.78 | -0.69 | -0.47 | 1.93 | 1.19 |
| 6-Nov-01 | 1:58:08 | 30ja01aa.14930.30448.603396.80 | -0.16 | 0.06 | **3.08** | 1.81 | -0.69 | -0.4 | -0.67 | -0.81 |
| 11-Dec-01 | 7:27:38 | 18mr01ab.11466.22338.373564.98 | -0.38 | -0.53 | **3.08** | 1.6 | -0.69 | -0.18 | -0.67 | -0.81 |
| 1-Dec-01 | 7:20:31 | 01fe01aa.21320.11090.997154.66 | 0.21 | 0.38 | 0.79 | 1.43 | **11.47** | **12.11** | 1.06 | 1.16 |
| 1-Dec-01 | 2:20:46 | 02mr01ab.9821.19474.367328.92 | -0.38 | 0.04 | 0.22 | -0.49 | **3.15** | 2.22 | -0.67 | -0.81 |
| 25-Dec-01 | 12:56:20 | 06ap01ab.471.22001.623562.168 | 0.21 | -0.16 | -0.35 | 0.38 | **3.15** | 1.71 | -0.67 | -0.81 |
| 18-Oct-01 | 4:26:10 | 17fe01ab.12355.23697.354830.88 | 0.14 | -0.36 | -0.35 | -1.44 | **3.15** | 0.55 | **3.66** | 1.2 |
| 21-Oct-01 | 11:04:29 | 26fe01ab.13959.16064.1022148.113 | 0.07 | 0 | -0.35 | -1.44 | **3.79** | 1.38 | **4.53** | 1.41 |

**Table 4. Z-Scores of Candidate SETI Signals. Z-scores are calculated for candidate SETI signals to reveal distance from mean in standard deviation units. Of these signals, the Best Spike from 06ja01aa.2899.15698.417318.128 packet is the further from the mean (13.82s)**

perhaps the analysis is representative of *normal* SETI@Home data packets, it is suggested that additional descriptive analysis be performed on a larger data set. Rather, the analysis is only a simple pilot study that demonstrates the value of descriptive statistics and presents the concept for larger scale investigations.

b. **Interrelationship of Data Categories:** It is unknown how common and related data categories are in nature. For example, it appears that spike candidate signals are more common than triplets. Is that a correct assumption? Further analysis is required.

c. **Integrity and Reliability SETI@Home Data:** For security reasons, the source code for SETI@Home is not available, as there is a need to have all participants performing the exact same analysis. If not, there would not be any control over the research and confidence in the results. SETI@Home is also concerned that a few people may want to deliberately corrupt the database and server. As a result of this security issue, the data results from the *SETSpy* log may be biased.

d. **Normality of the Data:** To the surprise of your author, analysis of three of the eight categories (Returned Gaussians, Returned Tripets, and Best Triplets) were slightly skewed (see Pearson's Measurement of Skewness in Table 2). This skewness may be caused by a variety of variables, such as small sample size or this skewness may be a common condition for this category. Certainly further investigation is warranted into why the data are skewed.

This data analysis serves to demonstrate the value of using descriptive statistics to quickly identify the center, dispersion, and outliers of large data sets. These days, statistical analysis such as the above can be very easily performed using a variety of software including spreadsheets or statistical software packages. It is suggested that this descriptive statistics concept can also be incorporated into SETI League procedures to quantify and verify candidate signals resulting from the *Project Argus* search.

Descriptive statistics have other valuable applications to the radio amateur. For example, to a first order approximation, an antenna's beam pattern approaches a Gaussian distribution. So, instead of defining 3dB beamwidth and 10 dB beamwidth, it would be appropriate to use +/- 1s beamwidth (with a 68 percent detection possibility), +/- 2s beamwidth (encompassing 95 percent of the signals), etc. Similarly, descriptive statistics could be used to estimate the probability of detection of a given signal with a given station, the probability of completing a contact through a given satellite, or

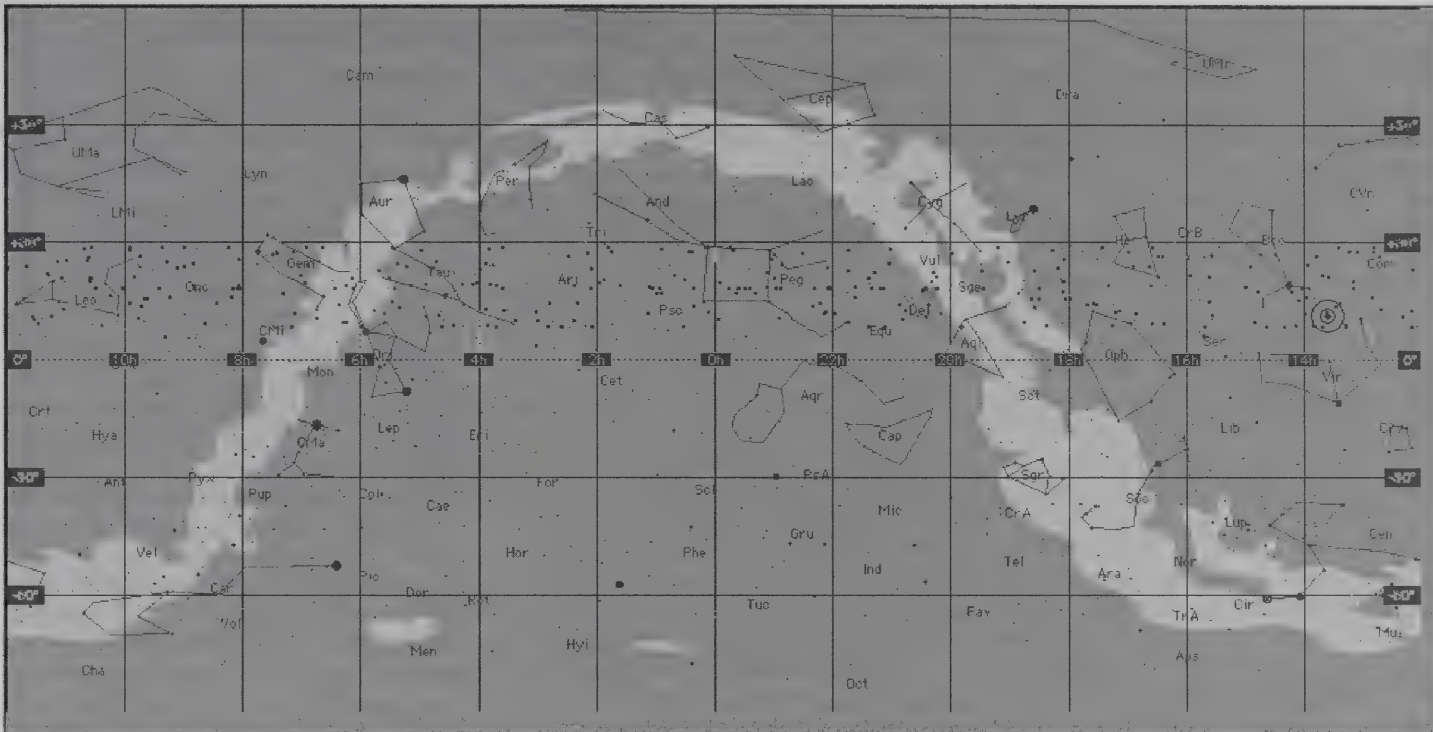


**Figure 6. A Reverse Image Showing the Sky Location of the K5NRK SETI@Home Data Analysis. This sky map provides the location of sky surveys performed by University of California Berkeley by the Arecibo dish in Puerto Rico. Each dot identifies SETI@Home data analysis performed by K5NRK. Also note the Arecibo dish can only perform sky surveys between 0° and +30° Declination or about 15 percent of the sky. Is this 15 percent of the sky representative of the entire sky?**

quickly analyzing large volumes of satellite telemetry.

### Conclusions and Acknowledgements

This article serves to demonstrate the value of using descriptive statistical analysis as a first step in analyzing large data sets. Readers are urged to pursue additional sources for clearly understanding the value of normal and abnormal observations. However, the best experience is to perform a descriptive statistical analysis on a data set. Knowledge of these conditions will enhance the reader's ability to measure, quantify, and describe normal and abnormal observations that are primary building blocks in analyzing and understanding large volumes of SETI data and amateur satellite telemetry.

The author thanks Dr. Thomas Clark, W3IWI and Dr. H. Paul Shuch, N6TX for their review, comments, and inspiration.

### Notes and References

1. For additional details on The SETI League please refer to *http://www.setileague.org/general/setihome.htm* and the following articles:

a. "*Project Argus*: An Amateur SETI Update," by H. Paul Shuch, N6TX, *The AMSAT Journal*, March/April 2001.

b. "Introduction to Amateur SETI," by H. Paul Shuch, N6TX, *The AMSAT Journal*, September/October 1997.

c. Shuch, H. Paul, *Tune in the Universe: A Radio Amateur's Guide to the Search for Extraterrestrial Intelligence*, American Radio Relay League, 2001.

2. For additional details on SETI@Home visit their WWW site at *http://setiathome.ssl.berkeley.edu/*

3. All AMSAT members are invited to participate in the AMSAT SETI@Home team. To join, visit the SETI@Home WWW page via reference 2.

4. Clark, Thomas A., *AMSAT's Presence in SETI Search*, 19th AMSAT Annual Meeting and Space Symposium, Decatur, GA, October 2001. Readers are urged to listen to W3IWI's presentation via Real Audio® via the Houston AMSAT Net WWW page at *http://www.amsatnet.com/*. Included in this presentation is an interesting history on the roots of SETI data collection in which W3IWI played a key role.

*5. SETISpy* is freeware available via *http://pages.tca.net/roelof/setispy/*

6. From SETI@Home glossary of definitions page: *http://setiathome.ssl.berkeley.edu/reference/*

7. The UC Berkeley SETI Program, **SERENDIP** (Search for Extraterrestrial Radio Emissions from Nearby Developed Intelligent Populations) is an ongoing scientific research effort aimed at detecting radio signals from extraterrestrial civilizations. The project is the world's only *piggyback* SETI system, operating alongside simultaneously conducted conventional radio astronomy observations. Currently piggybacking on the 1,000-foot dish at Arecibo Observatory in Puerto Rico is SERENDIP IV, the latest SERENDIP instrument, consisting of 40 spectrum analyzer boards working in parallel to look at 168 million narrow (0.6Hz) channels every 1.7 seconds. It is essentially a 200 billion-instructions-per-second supercomputer. For additional information on SERNDIP see: *http://seti.ssl.berkeley.edu/serendip/*

8. Your author can't help but try to describe how far 30s units is from the mean, and as a result, how rare an event it may be. For example, baseball hitting greats Ted Williams and George Brett batting averages were 4.24s and 4.08s from the mean of *normal* major league baseball averages (about 0.260). Super-athletes with batting averages like Williams and Brett come along only once in every 100,000 major league baseball players. Meanwhile a 30s unit event occurs about once in every $4.55^{e37}$ times! However keep in mind that a *nearby signal* such as a LEO satellite can appear as a strong signal from the norm. ■

# Field Ops Update: AMSAT Area Coordinators Listing

**Barry A. Baines, WD4ASW, *wd4asw@amsat.org***

Once again we present our annual listing of AMSAT-NA's Area Coordinators. In this issue you will find a listing of the 194 Area Coordinators in the U.S., Canada, and U.S. Territories (plus 5 country representatives) who donate their time and energy to help represent AMSAT within their respective communities. These volunteers may give programs to local clubs, serve as 'Elmers' to folks getting started in amateur satellites, and establish AMSAT nets on local repeaters. Other activities that Area Coordinators have done include organizing local AMSAT gatherings and supporting AMSAT Field Day activities. They serve as 'Ambassadors of AMSAT' in that they become the local contact for people needing information on the amateur satellite program. Through close coordination with AMSAT-NA Office Manager Martha Saragovitz, who provides AMSAT banners and materials when requested, they represent AMSAT at hamfests and swap meets as well as lead AMSAT presentations at these gatherings as well. A number of volunteers have done AO-27 and UO-14 demonstrations at hamfests, for example, which always generates interest and enthusiasm and which demonstrates to their communities what the amateur satellite program is all about.

AMSAT-NA has been blessed by a number of people who have stepped forward to volunteer as Area Coordinators around the country. We currently have Area Coordinators in 48 states and 5 Canadian Provinces, as well as Puerto Rico and the US Virgin Islands. Given the need to show the flag throughout North America, we continue to look for volunteers everywhere. You will note that there are two states where we don't have a designated Area Coordinator (Delaware and Idaho). There are eleven other states in which there is only one Area Coordinator. Even in States where we have multiple Area Coordinators, we still lack Area Coordinators in heavily populated areas nor do we enjoy even distribution of Area Coordinators around a given State. Field Operations representation is particularly needed in areas such as California (Los Angeles), Florida (Panhandle), Illinois (Chicago), Massachusetts (Springfield-West), New Jersey (Newark and the Northern half of the State), New York (NYC and suburbs), Ohio (Cincinnati, Cleveland), Pennsylvania (Allentown/Northeast), Tennessee (Nashville-Memphis), North Carolina (Raleigh-Durham to Wilmington), and the DC area. In Canada, we can also use support in the Eastern Provinces (Quebec, Newfoundland, New Brunswick, Nova Scotia) as well as Saskatchewan and Manitoba. The need for local AMSAT involvement in these areas is a need that has been identified in the past.

The importance of having Area Coordinators in these areas as well as improving coverage in existing areas cannot be understated. AMSAT's ability to increase interest in the amateur satellite program is dependent in part upon creating and maintaining both individual interest and general knowledge within the amateur radio community of using Amateur Radio satellites. As was noted in past issues of *The AMSAT Journal*, AMSAT has not been represented at several large hamfests because we don't have points of contact close enough to take advantage of these opportunities. Likewise, when contacted by several clubs looking for local AMSAT representatives to provide a club presentation or for technical support, we could not meet their requests on the local level. Our lack of volunteers to address these situations results in failure to develop support for the amateur satellite program, lost membership opportunities, and missed revenue through distribution of AMSAT materials. More importantly, not being seen means that our message is not being heard.

An additional consideration is the availability of volunteers to serve as local contacts regarding AO-40 operations. AMSAT continues to need a cadre of AMSAT members who are prepared to build awareness of amateur radio's most sophisticated satellite. The launch of NO-44 (PCSat) and NO-45 (Sapphire) last Fall also provides new opportunities for satellite communications, and the capabilities of these satellites need to be made more public. Finally, AMSAT's recent announcement concerning construction of a 'Microsat' class satellite will further increases the need to build awareness of new capabilities, particularly given the projected ability to use FM radios for contacts via this new satellite. As you can see, we can use some assistance in educating the amateur population of where they can get this information and encourage new satellite operators to try AO-40 and these other new services.

To help provide our area coordinators with presentation materials, we have developed a *Field Operations Resource Toolkit* on CD-ROM that was mailed to each Area Coordinator in North America in the Spring of 2001. A new CD-ROM containing updated material will be sent the Field Ops Team later this Spring. These CD-ROMs contain full-featured PowerPoint presentations that cover areas such as AO-40, Amateur Radio on the International Space Station, and *Introduction to Amateur Radio Satellites*. Each of these briefs is suitable for both club presentations and serving as a 'slide show' for displaying at an AMSAT display at a hamfest. There are also WAV files of various satellite related activities, such as *Mir* and the digitalker on the Fuji satellites. We also continue to maintain *The AMSAT Resource Guide*, which is an excellent summary of information sources on Amateur Radio satellites that is appropriate for use as a handout at club presentations and distribution to new members.

You can check the latest version of the Area Coordinators Listing by going to the AMSAT web page (*www.amsat.org*) and selecting "Find Your Local Area Coordinator." Links are also available under the "Who's Who page," on the AMSAT-NA organizational information page, and in the A-to-Z index. Thanks to the efforts of Jim Sanford, WB4GCS, the web listing provides a means for both newcomers and our AMSAT members to obtain this information as easily as possible as well as provide a means for our Coordinators to verify the accuracy of their individual listing. Should you have thoughts or comments about improving the Field Ops information pages on the AMSAT web site, please take a moment to convey your suggestions to me.

Our list of volunteers includes "Country Representatives" who are AMSAT-NA members living outside North America and perform fulfill the same functions as Area Coordinators in North America. These volunteers live in countries that don't host a national AMSAT organization. Having these individuals identified on our listing is another means of supporting the Amateur Radio satellite program as well as provides a mechanism for providing technical and informational support for individuals who are willing to encourage Amateur Radio satellite activities in their local communities.

Thinking of joining the Field Operations Team? The qualifications needed for being an Area Coordinator are simple: You must be a current member of AMSAT-NA, be willing to work with people, and have an interest in representing the organization as your time

and interests permit. In order to maintain contact with members of our Field Ops Team and provide them with support materials as needed, we also require each Area Coordinator have Internet electronic mail capability. E-mail provides an easy and cost effective avenue for distributing information, sharing ideas, and responding to requests for support. Given the variety of satellites in current use and the diversity of interests, Area Coordinators are not expected to know everything about the amateur satellite program. What is important is that each Area Coordinator be willing to find answers to questions and follow up with individuals looking for assistance. That's why we require electronic access, so that everyone can get information from other Area Coordinators and respond to queries in a timely manner.

If you are interested in serving as an Area Coordinator or learning more about the Field Organization, please contact me via:

- E-mail: wd4asw@amsat.org
- Telephone: 904-398-5185 (home) or 904-359-1933 (work)

### Dayton Hamvention

The upcoming Dayton Hamvention is quickly approaching! The weekend of 17-19 May 2002 promises to be an exciting time. As this is being written in late February, AMSAT's plans are in the process of being finalized, but keep in mind the following:

• The AMSAT booth will be at the same location as previous years (booth spaces 445-448). Please take a moment to checkout what will be offered this year as well as say 'hello.'

• The AMSAT Dinner on Friday evening, May 17 will be at the Amber Rose Restaurant (same location as the past few years). Nancy Mackey, KC8GYW and Dave Misek, N8NPX are coordinating this year's dinner. During last year's dinner, everyone enjoyed the presentation given by Gerry Schmitt, KK5YY describing his serving at a remote check station on the Iditarod Dog Sled race and working the satellites from Alaska. Based upon the success of having a dinner speaker, there will be a speaker this year as well. Expect an interesting talk when Bob Bruninga, WB4APR will make a presentation on APRS as well as NO-44 (PCSat).

• The AMSAT Forum will be Saturday morning, 18 May from 0815-0945 hrs. See ya at Hamvention! ■

## AMSAT-NA Area Coordinators

| State | Call | Name | Address | City | Zip | Home Phone | E-mail |
|---|---|---|---|---|---|---|---|
| AK | AL7EB | Ed Cole | P.O. Box 8672 | Nikiski, AK | 99635 | (907) 776-5829 | al7eb@amsat.org |
| AK | N1TX | Larry Ledlow | P.O. Box 84978 | Fairbanks, AK | 99708 | (907) 488-8399 | n1tx@amsat.org |
| AK | WL7BQM | Mike West | P.O. Box 452 | Sterling, AK | 99672 | (907) 262-5930 | wl7bqm@amsat.org |
| AL | K2SAT | Joel B. Black | Rte. 3 Box 52 | Eutaw, AL | 35462 | (205)372-2187 | k2sat@amsat.org |
| AL | KE4BF | Jimmy Potter | 94 Widgeon Drive | Scottsboro, AL | 35769 | (256) 259-1199 | ke4bf@amsat.org |
| AL | KX4Y | Dieter Schliemann | 1803 Roseberry Drive | Scottsboro, AL | 35769-3960 | (256) 259-3900 | kx4y@amsat.org |
| AL | N4NR | Dennis Dease | 2588 Royal Way | Pelham, AL | 35124 | (205) 733-9975 | n4nr@amsat.org |
| AL | N8DEU | Tim Cunningham | 109 Woodrow Balch Drive | Huntsville, AL | 35806 | (256) 837-8940 | n8deu@amsat.org |
| AR | KC5MLC | Gary Hollowell | 2011 Hwy 32 West | Ashdown, AR | 71822 | (870) 542-7158 | kc5mlc@amsat.org |
| AR | WC5I | Mark Manes | 109 Maple Shade Road | Alma, AR | 72921 | (501) 632-4276 | wc5i@amsat.org |
| AZ | AA7KC | Jim Weisenberger | 6502 E. Pebble Dr. | Mesa, AZ | 85215-2938 | (602) 985-2641 | aa7kc@amsat.org |
| AZ | N7HPR | Steven Bible | 2470 W. Thompson Way | Chandler, AZ | 85248 | (480) 726-9953 | n7hpr@amsat.org |
| AZ | W7LB | Larry Brown | 2721 S. Black Moon Dr. | Tucson, Az | 85730 | (520) 886-1957 | w7lb@amsat.org |
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| WY | N0AH | Paul Veal | 4655 Rd. 207 | Carpenter, WY | 82054 | (307) 649-2286 | n0ah@amsat.org |
| **US Territories** | | | | | | | |
| PR | KP3A | Asdrubal A. Lugaro | P.O. Box 998 | Hatillo, Puerto Rico | 00659 | (787) 820-6937 | kp3a@amsat.org |
| VI | NP2L | Malcolm Preston | Box 1318 | Cruz Bay, VI | 00831 | (340) 693-8782 | np2l@amsat.org |
| **Canada** | | | | | | | |
| ON | VE3FRH | Robin Haighton | 2028 Cheviot Court | Burlington, Ontario | L7P 1W8 | (905) 332-6134 | ve3frh@amsat.org |
| ON | VA3DH | Danny Huton | 1485 Thetford Court | Mississauga, Ontario | L5J 3N2 | (905) 823-7129 | va3jdh@amsat.org |
| ON | VA3EJN | Richard John Norwood | 16 Birchlea Ave. | Etobicoke, Ontario | M8W 1E9 | (416) 255-0079 | va3ejn@amsat.org |
| ON | VE3SAT | Dave Oman | 330 Winnifred Drive | Keswick, Ontario | L4P 3B5 | (905) 476-5973 | ve3sat@amsat.org |
| AB | VE3FAL | Fred Lesnick | 2060 Hwy 60 | Thunder Bay, Ontario | P7J 1B9 | (807) 622-2617 | ve3fal@amsat.org |
| BC | VE6ITV | Scott Smith | Box 4462 | Barrhead, Alberta | T7N1A3 | (403) 584-2517 | ve6itv@amsat.org |
| BC | VE7VVW | Ron Seiler | 4001 15th Crescent | Vernon, BC | V1T 7H5 | (250) 545-3124 | ve7vvw@amsat.org |
| BC | VE7XQ | Tony Craig | 20691 - 45A Ave. | Langley, BC | V3A 3G3 | (604)-534-1296 | ve7xq@amsat.org |
| PQ | VE2DWE | Luc Leblanc | 125 Des Chenes | Sorel-Tracy, PQ | J3P 5T6 | (450) 743-8676 | ve2dwe@amsat.org |
| MB | VE4XA | Bob Mitchell | P.O.Box 637 | St. Malo, Manitoba | R0A 1TO | (204) 347-5120 | ve4xa@amsat.org |
| **Country Representatives** | | | | | | | |
| | HH2B | Bernard Russo | P.O. Box 38 | Port au Prince, Haiti | | | hh2b@amsat.org |
| | HR2KOS | Ricardo 'Rick' Denis | P.O. Box 1224 | San Pedro Sula 21105, Honduras | | (504) 53-0136 | hr2kos@amsat.org |
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| | DU1EV | Eduardo J. Valdez | P.O. Box 169, UP Diliman | Quezon City, 1144 Phillipines | | (917) 814-2038 | du1ev@amsat.org |
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## AMSAT Journal Telemetry

### Call for AMSAT Board of Directors Nominations

It is time to submit nominations for AMSAT-NA Board of Directors. AMSAT member societies or five current individual members may make nominations of fellow members to serve a two-year term. Three seats on a seven-member board must be filled this year. Those who terms are expiring are: Tom Clark, W3IWI, Keith Baker, KB1SF and Bruce Paige, KK5DO. Bruce replaced Andy MacAllister, W5ACM who resigned last month. Please be sure that anyone you nominate understands that meeting attendance is necessary. Nominations should be marked Board of Director Nomination and sent to AMSAT, 850 Sligo Avenue, Suite #600, Silver Spring, MD 20910 (no e-mail nominations) and must arrive by 15 June 2002.

### Results of Straight Key Night on OSCAR 2002

Many thanks to all who participated in Straight Key Night on OSCAR 2002 which was the first to make use of AO-40. Here is the list of *Best Fist* winners, each of whom received at least one nomination from an operator he worked during the event:

- Charlie Suckling, G3WDG
- Cliff Buttschardt, K7RR
- Frank Wiesenmeyer, K9CIS
- Vic Politi, W1NU
- Pete Lawn, WA6DFU

See you all next year and 73, Ray Soifer, W2RS

### Contributor List

To further acknowledge your assistance, AMSAT is compiling a list of contributors for publication in *The AMSAT Journal*. The plan is to include donors' names and call signs in a future issue of *The AMSAT Journal*. If you prefer not to have recognition published, please, notify Martha at AMSAT-NA, 850 Sligo Avenue, Suite 600, Silver Spring, MD 20910-4703, e-mail to *martha@amsat.org*, or telephone 301-589-6062.

### Honors for Martin Sweeting, G3YJO

Ray Soifer, W2RS has noted that the United Kingdom's 2002 Honors List included a knighthood for Martin Sweeting, G3YJO, "for services to microsatellite engineering." Ray passed on his congratulations, noting this very well-deserved recognition and the many achievements of G3YJO. AMSAT-NA President Robin Haighton, VE3FRH, also noted the achievement:

*Hello Sir Martin,*

*It was with great pleasure that I learned of your recent appointment. Your work with SSTL and both from an educational viewpoint and the development of satellites with international implications brings great credit to you and your colleagues. On behalf of AMSAT-NA, the Board of Directors, Officers and Members, may I offer you our congratulations on this appointment.*

*A very Happy New Year and 73,*

*Robin Haighton VE3FRH, President, AMSAT-NA*

*Dear Robin,*

*Many thanks indeed for your kind note - I have to say that I was totally surprised and am somewhat awed by receiving this honour. I am very aware that achievement comes not from just one person but is the result of teamwork, support and friendships without which nothing would have been possible. I hope that this recognition of our work will benefit all concerned at Surrey and in AMSAT and that we can continue to strive for new challenges!*

*It is especially nice to hear from friends in AMSAT as I recall the times spent in DC during the genesis of UoSAT-1 and I owe a considerable debt of gratitude to Perry Klein, Tom Clark, Jan King, and Dick Daniels for their generous support in those early days. I never dreamt at that time that I would be so fortunate as to have my hobby become my career in this way. Although inevitably different now, I still find it as exciting as those early days. Thanks again and my very best wishes for the New Year!*

*Yours,*

*Martin, G3YJO*

### New OSCAR Designations

Bill Tynan, W3XO, has announced OSCAR designations for two new amateur satellites. PCsat will be known as NAV-OSCAR-44 (NO-44). PCsat is a 1200-baud APRS digipeater designed for use by amateurs using hand-held transceivers or mobiles. The spacecraft known as Sapphire has been designated NAV-OSCAR-45 (NO-45). Sapphire has 1200-baud AX.25 telemetry and a voice replay on 437.1 MHz. PCsat is a project of the Small Satellite Program within the US Naval Academy's Department of Aerospace Engineering, and Sapphire is a joint effort involving the Naval Academy's Small Satellite Program, Stanford University and Washington University at St. Louis. Both were launched 01 October 2001from Alaska.

### ARISS Antenna Installation Successful

Amateur Radio on the International Space Station (ARISS) Board Chairman Frank Bauer, KA3HDO, recently congratulated the ARISS-International team on the successful installation of the first of four ham radio antennas on ISS. Those that watched the NASA TV video were afforded an outstanding view of the first ISS ham antenna installation EVA, which was performed by Cosmonaut Yuri Onufrienko and Astronaut Carl Walz. "It was exciting to see the unfurled ISS ham antenna system permanently mounted on the outside edge of the service module," said KA3HDO, adding, "the antenna system looked breathtaking from the videos we witnessed while supporting the EVA activity."

Lou McFadin, W5DID, Frank Bauer, KA3HDO, Mark Steiner, K3MS, Ken Nichols, KD3VK, and Mark Clausen supported the ISS antenna installation at the NASA Goddard/ISS Ham-Goddard Control Center. Carolynn Conley, KD5JSO, provided the antenna installation support at the NASA Johnson Space Center Mission Control Center. Sergej Samburov, RV3DR, Alex Polechuk, RZ3FP, cosmonaut Sergei Krikalev, U5MIR, and Alex Alexandrov, RK3AP, supported the EVA activities at the Mission Control Center in Moscow.

"Congratulations team on a job well done. We have taken our ideas, concepts and vision and transformed them into reality," said KA3HDO. The first space walk of the Expedition-4 crew's five-month tour of duty lasted just over 6 hours. The spacewalk was the 32nd in support of space station assembly.

The next spacewalk of the expedition is targeted for late January. The plan for this spacewalk currently includes installation of the second of the remaining three Amateur Radio antennas, along with thruster deflector shields on the end of the Zvezda module.

**Recently, Keigo Komuro, JA1KAB, visited Dick Flagg, AH6NM and Nancy Rocheleau, WH6PN at the Sacred Hearts Academy in Honolulu, HI. Keigo is one of the two ARISS delegates from Japan and is also active on the ARISS Administrative and Educational Outreach/School Group Selection Committee. AH6MN and WH6PN operate a telebridge station that has made many ARISS school contacts. (photo by Dick Flagg, AH6NM)**

## Silent Keys

**Steve Grant, N8AJD** was born on 22 December 1950; he died, too soon, in early January of this year. He was an avid ham, always ready to help others. He was heavily involved in volunteer work in particular for AMSAT. He was Area Coordinator for SE Ohio and as such he conducted a weekly net, which featured live demonstrations of satellite communication. He specifically was active on the digital satellites. He arranged several AMSAT Symposia in smaller Ohio cities and lent a helping hand to AMSAT at the Hamvention and other Ohio ham fests. He maintained a 6m beacon for Ohio on 50.103 MHz. He was also a member of SETI and checked into the QRZ-Web-Ring. We sure will miss him. [WB8IFM]

**Craig Mellinger, N2MNA:** Jim Kelly, KK3K, informed the AMSAT-NA bulletin board that long time satellite enthusiast and DXer, Craig Mellinger, N2MNA, of Parsippany, New Jersey, died in his sleep on 10 January 2002. Craig developed Parkinson's disease several years ago. His condition forced him to retire early from his job in sales. Craig's condition worsened after the recent holidays. "Craig was a good and loyal friend," said KK3K, "and remained an active ham as long as he was able." Craig was well known on the AO-13 Mode B transponder. His sense of humor and good nature — combined with his willingness to be helpful — will be missed. Gene, WB9MMM, remembered Craig's column in the *OSCAR Satellite Report*. Chip, K7JA, noted that Craig "was a great help to many satellite enthusiasts over the years, and really had his heart into everything he did." Craig Mellinger's family has suggested donations to the Parkinson's Alliance organization, at 211 College Road East, 3rd Floor, Princeton, New Jersey 08540.

## ARRL & TAPR Digital Communication Conference Call for Papers

Technical papers are solicited for presentation at the 21st Annual ARRL and TAPR Digital Communications Conference to be held 13-15 September 2002 in Denver, Colorado, and publication in conference proceedings. The conference location is the Denver Marriott Southeast Hotel, 6363 E. Hampden Ave., Denver, CO 80222. Annual conference proceedings are published by the ARRL. Presentation at the conference is not required for publication. Submission of papers is due by 05 August 2002. Conference registration details and updates are available at http://www.tapr.org/dcc.

The ARRL and TAPR Digital Communications Conference is an international forum for radio amateurs to meet, publish their work, and present new ideas and techniques. Presenters and attendees will have the opportunity to exchange ideas and learn about recent hardware and software advances, theories, experimental results, and practical applications as well as updates on AX.25 and other wireless networking protocols. E-mail your paper to Maty Weinberg at ARRL HQ at *maty@arrl.org*.

## Annual VHF Conference Dates Set

The Southeastern VHF Society invites ANS readers to attend the 6th Annual Southeastern VHF Society Conference in Oak Ridge, Tennessee. The announced dates are April 26-27, 2002. The conference promises to be an interesting event, with many presentations by accomplished VHF enthusiasts from around the U.S.A. In addition, the conference will feature antenna gain, pre-amp gain and noise figure measurements, a Friday evening flea market with vendor displays, a Saturday afternoon auction and the Saturday evening banquet. Registration, program details, hotel and travel information can be found at *http://www.svhfs.org/*.

The Central States VHF Society will be holding its 36th Annual Conference this year in Milwaukee, Wisconsin. The dates are July 26-28, 2002. Interested authors are invited to present a paper for the Conference. Any topic related to weak-signal VHF operation is welcome, including antenna designs, pre-amp concepts, modern meteor scatter techniques and software, satellite operations (especially AO-40), PSK-31 and its applications at VHF, roving tips and techniques, and EME operation with small dishes.

Papers are welcome in either paper or electronic format, but will be required by May 5, 2002 to be included in the Proceedings document. If interested in writing and/or presenting a paper for the 2002 CSVHFS Conference, please send an e-mail to *n8kwx@csvhfs.org* For more information about the 2002 CSVHFS Conference visit *http://www.csvhfs.org/CSVHF02.HTML*.